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10 February, 2003

The Head
Department of Educational Research
and Policy Perspectives (DERPP)
National Council of Educational Research and Training
Sri Aurobindo Marg
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Final Research Report Submitted through the Proper Channel

Sir,

Subject An ERIC project entitled "A Study of Sequence of Logical Thinking Operations in Mathematics among Disadvantaged Children" submission of final report

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With reference to the above, I am pleased to inform you that, the above research project sponsored by the ERIC has been completed within the stipulated period of two years. Please find enclosed herewith a copy of the Final Report and the Executive Summary sent through the proper channel The remaining two copies of the Final Report and two copies of the Executive Summary will be sent to you directly

I wish to express my sincere thanks to the Educational Research Innovations Committee (ERIC), Department of Educational Research and Policy Perspectives (DERPP), National Council of Educational Research and Training (NCERT), New Delhi for having sanctioned the present research project and for providing adequate funds for the same

Thanking you,

Yours faithfully,

Kasinath

(H M Kasinath)
Principal Investigator

FWCs through the Chairperson, Department of Education, Karnatak University, Dharwad.

No KU/PG/EDN/2002-2003/554
Date 10/2/2003

A STUDY OF SEQUENCE OF LOGICAL THINKING OPERATIONS IN MATHEMATICS AMONG DISADVANTAGED CHILDREN

MAJOR RESEARCH PROJECT
SPONSORED BY THE EDUCATIONAL
RESEARCH AND INNOVATIONS COMMITTEE
(ERIC), NCERT, NEW DELHI

Dr. H. M. KASINATH
Principal Investigator
Department of Education
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DHARWAD

A MAJOR RESEARCH PROJECT REPORT
SUBMITTED TO THE DEPARTMENT OF EDUCATIONAL RESEARCH
AND POLICY PERSPECTIVES (DERPP), NATIONAL COUNCIL OF
EDUCATIONAL RESEARCH AND TRAINING (NCERT), NEW DELHI
FEBRUARY, 2003

ACKNOWLEDGEMENT

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I am specially indebted to the chairperson Dr (Smt) Shashikala Deshpande, Professor and Dean of the Faculty of Education, Department of Post-graduate Studies in Education, Karnatak University who permitted me take up this research project and provided me all the facilities during the period of my research work I am also thankful to Dr. K. Ramachandrachar, Former Professor, Chairman & Dean of the Faculty of Education who has forwarded the research proposal to the ERIC, NCERT, New Delhi.

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I wish to express my thanks to the members of the staff of the secondary schools and students of the IX Standard who are involved in data collection and on whom the present study in conducted. Without their active cooperation, it would certainly have not been possible to conduct the present investigation.

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My special thanks are due to Sri V. B. Mathad who guided me in maintaining the accounts of the research project and also to Sri Srishaila Patil who gave final touch to the research report

Dr. H. M. KASINATH
Principal Investigator

PREFACE

This is the report of Research Project entitled 'A Study of Sequence of Logical Thinking Operations in Mathematics among Disadvantaged Children' which was sponsored by the Educational Research Innovations Committee (ERIC), National Council of Educational Research and Training (NCERT), New Delhi.

It is a matter of common knowledge that 'thinking' is an essential commodity in day-to-day life. School subjects will have to give emphasis to the process of thinking. Usually thinking involves logical operations like observation, coding, inference, application and problem solving The study of mathematics should help to develop the thinking operations like observation, logical thinking, reasoning, invention, etc. It is felt that mathematics has failed to develop these thinking operations in school children. The problems and illustrations given in mathematics textbook are not encouraging the development of thinking abilities like imagination, concentration, memorization, observation, invention, reasoning, abstracting, analyzing, synthesizing, etc., especially among disadvantaged, rural children. This necessitated to study how for the mathematics teaching in present day schools is successful in developing these logical thinking operations among disadvantaged children. It may be pointed out here that systematic studies in this area are conspicuous by their absence. This is the context in which the present study is undertaken.

I sincerely hope and pray that the project report shall be found useful for bringing suitable reforms in our educational system for vitalizing mathematics education at the secondary level and would also pave a way for initiating more researches in this area.

Dr. H. M. KASINATH
Principal Investigator

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INTRODUCTION

1.1 Place of Mathematics in Secondary School Curriculum

Mathematics has played a pre-dominant role not only in the advancement of civilization in general but also in the development of physical sciences and has now far wider application in other branches as well. Mathematics has been an inseparable part of school curriculum ever since the beginning of formal education and it continues to be so. The mathematics curriculum has undergone various changes from time to time in accordance with the changing needs of the society.

Kothari Commission (1966) has wisely remarked that, 'one of the outstanding characteristics of scientific culture is quantification. Mathematics therefore, assumes a prominent position in modern education Apart from its role in the growth of the physical sciences, it is now playing an increasingly important part in the development of the biological sciences The advent of automation and cybernetics in this country marks the beginning of the new scientific - industrial revolution and makes it all the more imperative to devote special attention to the study of mathematics. Proper foundations in the knowledge of the subject should be laid at school'. (IEC, 1966)

Realizing the need of the social necessities, Education Commission set up in 1964 recommended that Mathematics should

be taught as a compulsory subject of general education up to Class X. Provision of differential courses and additional or elective courses, defeats the philosophy and purposes of general education and there could be just one course in Mathematics for all Only international numerals (Hindu-Arabic numerals) symbols, conventions should be used right from Class I onwards Since general education envisages Mathematics for all, the selection of content should be relevant to the practical needs of everyday life. The load of Mathematics curriculum should be realistic While designing the curriculum for the primary level, the existence of a large number of single teacher schools, high dropout rate, unfavourable socio-economic conditions of a major segment of society, etc., should be kept in view

The value or usefulness of bringing in calculators/computers into the Mathematics education system is recognized. However, many of the mathematicians are of the view that due to unsatisfactory socio economic conditions of a vast majority of population, making the use of calculators compulsory or even optional is not desirable. On the other hand, many feel that the use of calculator after a certain stage up to which students are familiar with the process of multiplication, division, addition and subtraction and use of computer should be allowed as it helps in doing the problem quickly and provides more time for them to learn. However, by and large, it is agreed that training in the use of calculators and other mathematical apparatus is

desirable and should be imparted to all at a convenient point of school education.

The place of mathematics in secondary schools cannot be undermined It has to play its own part in shaping the future generation of the country. India after independence is striving hard to improve herself into all her commitments whatever may be the sphere Only individual and technological developments will extend its helping hand in making India an advanced country. To achieve this development the knowledge of mathematics is essential. The proficiency in mathematics complements to the proficiency in science knowledge. The future of India should be shaped only in the Indian classrooms. In order to make Indians better citizens, secondary school curriculum should be so formulated that proper importance be given to mathematics

Mathematics is very useful subject for most vocations and higher specialized courses of learning But everybody who is studying it in the school is not going to be an accountant, engineer or statistician. But at such an early stage of education it is difficult to know who is going to be an engineer or banker. Psychologists, however, have shown that it is possible at this stage to determine what student could be in later life. Therefore the duty of the school is to give to the high school student a broad view of what he is capable of achieving in future. He should get a broad course to be able to choose a suitable line out of that. Regarding this point Bajpai (1972) opines

that 'secondary education is the backbone of university education. At the primary and secondary stage, the greatest impact of the present changes will be felt The future development of the country depends on mathematical knowledge that is gained in the primary and secondary education. If the individual understands each and every step in this stage he feels happy and gets success In view of the above facts it is not merely necessary but it is urgent to discuss what developments are desirable and means by which they can be achieved at the secondary level' (pp 33-40).

In 1932, Executive Board of the Progressive Education Association (America) established the Commission of Secondary School Curriculum This Commission subsequently established several committees to explore the respective contributions of various subject fields to general education at the secondary level; among them was the committee on the function of mathematics in general education This committee finally submitted its report in four parts. The first of these presents the educational philosophy, which guided the committee in the formulation of the report, central in this philosophy being the premise that mathematics in order to justify its place in the secondary school curriculum, must contribute to the satisfaction of the needs of the students. These needs are enumerated in terms of the following four basic aspects of living :

i. Personal living,
ii. Immediate personal-social relationships,

iii Social civic relationships, and

iv Economic relationships.

This part of the report closes with discussion of the role of mathematics in satisfying the needs of people with respect to these four aspects of living

Mathematics does help in training and disciplining the mind. It develops the power of thinking and reasoning and gives mental exercises best fitted for strengthening the faculties of the mind. Although the opportunities of such exercises may also be given in the studying of other subjects, but mathematics enjoys a unique position in this respect, Young remarks 'Mathematics is the only subject that encourages and develops logical thinking It enables the student to determine between essentials and non essentials'. Bread and butter value of the subject mathematics can hardly be denied Directly or indirectly mathematics does not only help everybody in earning but it helps in wise spending.

Mathematics is a social study because it has been developed to serve the personal and social needs of human kind. Mathematics is also a language in which carefully defined language and concise symbol representation are used. Mathematics is an integral part of aesthetic art because it is concerned with symmetry of form and order. Mathematics is a recreational study because it is used in may recreational pursuits and because people find pleasure and relaxation in delving into its content (Spencer, 1996).

This importance of mathematics in secondary school curriculum, at present has been considered and widely accepted as a subject that enables the child to develop rational and logical thinking, understanding of the percepts and concepts. The value and importance of mathematical ability has greatly increased so much that every man and woman of liberal education is expected to understand the use of quantitative data in the solution of social problems and use of mathematics in daily life.

Keeping all these points in mind, the Indian Education Commission (1966) remarked that, 'Science and Mathematics should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling In addition, there should be provision of special courses in these subjects at the secondary stage, for the students of more than average ability' (IEC, 1966)

National Policy on Education (1986) remarked that, 'Mathematics should be visualized as the vehicle to train a child to think, reason, analyze and to articulate logically. Apart from being a specific subject, it should be treated as a concomitant to any subject involving analysis and reasoning' (NPE, 1986.).

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With the recent introduction of computers in schools, educational competency and the emergence of learning through the understanding of cause-effect relationships and the interplay of

variables, the teaching of mathematics will be suitably redesigned to bring it in line with modern technological devices' (NPE, 1986).

1.2 Aims and Objectives of Teaching Secondary School Mathematics

1.2.1 Aims of Teaching Mathematics

Universally recognized aims or large purposes of teaching mathematics in secondary schools are as follows :

i. To give the individual an understanding of ideas and operations in number and in quantity needed in daily life by the citizens of our country as individuals;

ii. To develop in the individual an awareness of the mathematical principles and operations which will enable the individual to understand and participate in the general, social, and economic life of the community;

iii To provide through mathematical ideas, aesthetic and intellectual enjoyment and satisfaction and to give an opportunity for creative expression;

iv To provide the basis of mathematical skills and processes which will be needed for vocational purpose; and

v To help the child to develop mathematical skills and attitudes to meet the demands of (a) daily life, and (b) future mathematical work in the related field of knowledge.

1.2.2 Objectives of Teaching Mathematics

The following are the objectives to be achieved by the teaching of mathematics at the secondary stage, as presented in the guidelines and syllabi for secondary stage, (NCERT, 1988).

The teaching-learning process of mathematics should enable the child .

i. to consolidate the mathematical knowledge and skills acquired at the upper primary stage;

ii. to acquire knowledge and understanding of the terms, symbols, concepts, principles, processes, proofs, etc.;

iii. to develop mastery of basic algebraic skills,

iv. to develop drawing skills;

v. to apply mathematical knowledge and skills to solve real mathematical problems by developing abilities to analyze, to see inter relationship involved, to think and reason;

vi. to develop the ability to articulate logically;

vii. to develop skill in the use of mathematical tables for problem-solving;

viii. to develop ability to write, interpret algorithms for problem-solving;

Mathematics and on the other, Mathematics helps in improving technological devices. What should be the structure of mathematics up to 10 years of general education? What type of mathematics should be taught? It goes without saying that mathematical reasoning demands higher mental ability. Experiences have shown that the majority of students normally fail in Mathematics at the end of Class X. This frustrates not only students but also their parents. Many educationists feel that Mathematics should be compulsory only up to Class VIII, while some others opine that there should be two types of Mathematics courses at Secondary level and Senior secondary level. These courses should be need based. At Secondary level, there should be one course for those who will pursue Mathematics as their future career and another course for those for whom Class X will be a terminal stage. As such the important issue is what sort of mathematical skills and competency are required up to ten years of Mathematics Education.

Mathematics in some of the States has been made optional. Unfortunately, in some places in lieu of mathematics students especially girls offer Home Science. There is a strong feeling that Mathematics up to ten years of school should be functional and should not be loaded with Commercial Mathematics and Banking. Mathematics learning is badly affected due to the problem of the language in which books are written/developed. Concepts not properly communicated through the language of the textbooks or

content not properly understood by students creates problem While considering the compatibility of our Mathematics courses up to ten years of general education, some people strongly feel that topics of international importance may also be included in Mathematics, but these may not be made compulsory for all.

Like in Science, the concept of a Mathematics Laboratory has emerged as a new dimension and especially so in the urban schools. Activity-based Mathematics at school level is going to promote learning of Mathematics in a big way. The opinion across the teaching community and parents is that there is lot of wastage due to failure in Mathematics at secondary level, because the present content in Mathematics is not very relevant to the students' needs who would like to terminate their education at the secondary level itself.

In many schools, in absence of qualified teachers, non-mathematic teachers are teaching Mathematics. The basic question that we need to address ourselves for any futuristic concern is whether Mathematics Education can be left to the change of non-mathematics person, knowing well that maximum failure takes place in Mathematics. In order to reduce failure, this situation may have to be readdressed.

The use of calculators in Mathematics learning is yet another issue that needs to be debated. Mathematicians strongly feel that at the initial stages of school education, i.e., up to Grade VI or so there

should be no use of calculators. However, as soon as they reach Class VII they should be allowed to use calculators as by that time the basic principles of additions, subtraction, division and multiplication are clear to them.

1.4 Modern Mathematics Programmes in Indian Schools

The new mathematical programmes vary widely in their approach and implementation in different States of India. But all the programmes in different States lay stress upon the unifying themes or ideas in Mathematics, such as, pattern and structure, system of numeration, development of real numbers, set language, introduction of set notations, symbols for operations, matrices and their application to geometrical transformation, simple probability and statistics.

Generally speaking significant changes have affected our school mathematics programme. *Firstly,* the traditional courses of too much compartmentalization of arithmetic, algebra and geometry are substituted by new courses with emphasis on the basic mathematical structures, which have common underlying principles and properties. Memorization of number of facts has been replaced by reasoning and discovery of the principles involved in the commutative, associative and distributive laws of Mathematics. Hence, the emphasis in arithmetic is on the properties of number and the operations. Some simple algebraic ideas, mathematical sentences, equations, symbols etc., are introduced in the early stage of schooling. The ideas of space,

point, line and plane and well-defined unit of measurement have come at the elementary level itself. The set language and other number bases are used to give an idea of abstract structure of mathematics.

The *second* change is the use of qualitative vocabulary. In arithmetic, for example, there are such new terms and the concepts they embody as the sets, mapping or matching, numeral as distinct from number, one to one correspondence order, base operations and so on. In geometry the meaning and use of ideas implicit in the words like point, set of points, line, segment, ray, half plane and so on are developed.

The *third* change is that of understanding the why of computational operations, instead of how of using numbers mechanically in a memorized sequence of steps. In new mathematics programme, a student is required to learn that every bit of manipulation, which he does, has a reason. Considerable use is made of deductive reasoning and proof, and basic laws of logic are developed and used.

The *fourth* change is that the responsibility of learning is left to the child. The discovery method is utilized wherever appropriate. The student is led to make and test conjectures of his own and formulate some principles and procedures for himself. By exposure to different ways of approaching tasks, the students are encouraged to make their

own mathematics discoveries to develop mathematical insight, and to acquire an understanding of many mathematical ideas

1.5 Present Position of Teaching Mathematics

Despite the importance of mathematics, not sufficient attention is paid to teaching and learning of mathematics. For instance, in the words of Aiyengar (1973), "the amount of mathematics that Madras matriculate is expected to know is not as much as what a boy in elementary school in England or a boy of junior high school in America actually learns". The situation is not different in the case of teaching of mathematics at the secondary school level in other parts of India. Pupils generally show distaste or aversion towards mathematics. Aiyengar points out that students consider mathematics as 'a bug bare'. Mathematics is considered as a difficult subject requiring special aptitude and higher level of intelligence, which is not always true. Only average level of mental ability is required for learning mathematics, which is a prerequisite for learning any subject We can trace a number of reasons for the unfavourable attitudes towards mathematics on the part of pupils. Aiyengar has succinctly described some of the reasons as follows:

i. *Difficulty*· The view that mathematics is difficult subject is ill-founded because in mathematics the premises are obvious and the reasoning is simple. It is only in mathematics they can solve problems by applying the principles learned. In other subjects it is comparatively more difficult to arrive at definite and concrete

conclusions. Unlike in other subjects, rote learning does not help in mathematics; on the other hand, the students are to think for themselves. Only the dull pupil who are deficient in thinking and pupils who are left out in the present day mode of instructions find mathematics difficult.

ii. *Sequencing nature of the subject* . Mathematics consists of a set of principles and patterns in a number system each of which is organized just as the arrangement of bricks one over the other in building a wall. The implications of this hierarchical organization is that a student can grasp mathematical facts at a particular level and find learning interesting and meaningful only if he has adequate understanding of mathematical knowledge at the lower levels. In other words, a good foundation or background or footing in mathematics is required for learning higher mathematics Weakness in the knowledge of mathematics at one level of learning will carry over to other levels, with the result; the students lose interest in mathematics unless those weaknesses are remedied. Lapses at earlier stages cannot be fully corrected at later stages. So what is required is that right learning should take place at all levels which is possible when the student learns mathematics through understanding rather than by solving the problems mechanically, memorizing mathematical symbols and formulae. Ineffective teaching or wrong approaches to teaching mathematics can score away even the so-called 'brilliant' students or those who have required abilities, aptitude and initial enthusiasm. The real danger lies in making the pupils to solve the problems mechanically by using set norms and formulae rather than encouraging

them to think through the problems and come out with the solutions. There is a stereotypic view that the mathematics is a tough subject and requires superior intelligence, which infact is a 'myth'. This notion get circulated on from people to people making their beliefs stronger, this in turn demotivates them in pursuing studies in mathematics.

1.6 Achievement of Indian Secondary School Pupils in Mathematics

The broad objective of a national level survey report (NCERT) was to find out the achievement of pupils in mathematics at three levels of education - primary, middle, high school, all over India except Bihar and Tamilnadu. For this purpose 15,000 schools at each level were given the tests. The results revealed that the national performance was quite below the desired level. On the objective dimension items involving applications of concepts proved difficult. Similarly was the case with items that involved more reasoning rather than rote knowledge. In most of the States, items on objectives application and logical reasoning were comparatively difficult than those on the objective knowledge and skill. Comparing the average difficulty values of the items according to objective seemed to be application followed by logical reasoning, knowledge and skill. This trend appeared in most of the States. The students had failed badly on application of knowledge to new situations, logical reasoning, evaluation, synthesis and so on (Kulkarni and Mohanlal, 1970).

Patel (1984), among other things, discovered that the pupils possessing high reasoning ability were found to be better in mathematical ability than those with low reasoning ability (Patel, 1988, pp. 704-705)

1.7 Theoretical Framework for Thinking Skills

This part of the study presents the meaning and nature of thinking skills, importance of thinking skills, and importance of teaching for thinking. Theoretical framework for thinking skills introduces the reader to the present status of thinking skills among the pupils and also in the curriculum and the latest development in teaching for thinking skills as a theoretical background for this research study.

1.7.1 Meaning and Nature of Thinking Skills

Thinking is a world of metaphors and myths. The brain is often portrayed as a "private space" by earlier philosophers the so called Cartesian myth which Ryle describes as follows: the working of one mind are not witnessable by other observers; its career is private. Only one can take direct cognizance of the states and processes of one's own mind. A person . . . lives through two histories, one consisting of what happens in and to his body, the other consisting of what happens in and to his mind. Websters's twentieth century dictionary defines as :

"to bring the intellectual faculties into play, to use the mind for arriving at conclusions, making decisions, drawing inferences", etc ,

"to perform any mental operation to reason",

"to purpose, to intend, as I thought to help him";

"to judge, to conclude, to decide to hold as a settled opinion, to behave, as to think nobly of a person";

"to muse, to meditate, to reflect, to weigh something mentally".

Rath (1967) has put forward a number of concepts after a long research on "Teaching for Thinking". He evolved a theory and also the applications of his theory. Many examples of our behaviour are indicative both of thought and lack of thought. With respect to the latter, we emphasize eight rather common behavioural syndromes as associated with a habitual disregard for thinking processes. They are, impulsiveness, over dependence upon the teacher, dogmatic, assertive behaviour of the teacher, extreme lack of confidence among pupils, inability to concentrate, rigidity and inflexibility, missing the meaning and resistance to thinking.

"Thinking skills" is a way of looking at the problem. According to Nisbet (1993) and McGuinnes (1999), 'thinking' means the process of cognition, knowing, remembering, perceiving and attending. Skill means the act of collecting and sorting information, analyzing,

drawing conclusion, brainstorming, problem-solving, evaluating options, planning, monitoring, decision-making and reflecting.

Nickerson (1988), McGuinnes (1999) points out that different researchers have produced different taxonomies of thinking. Most include some or all of the following collecting information, sorting information, analyzing information, drawing conclusion from the information, 'brain storming' new ideas, problem-solving, determining cause and effect, evaluating options, planning and setting goals, monitoring progress, decision making and reflecting on one's own progress.

All are based upon the assumption that thinking (cognition) goes beyond the acquisition of knowledge (i.e., Ryle's 'knowing that') and include the process(es) of knowing about thinking (meta cognition) i.e., being able to reflect on the processes by which learners process information.

According to Beyer (1989), thinking skills are the activities applied to a specific learning task, the building blocks of thinking. According to him, thinking skills are the pre-requisites of higher order performance.

1.7.2 Thinking Operations in Mathematics

The study of mathematics helps us in the development of thinking operations like observation, coding, interpretation, inference,

analysis, synthesis, generalization, originality, discovery, application, problem-solving, comparing, clarifying, etc.

Some of the main thinking operations identified here are :

Observation:

Information acquired through senses is called 'observation'. Senses are the first and most basic mechanism for gathering information and observation depends on the sense data It is the process of determining the likeness and differences in single objects that vary in their physical characteristics as detectable by any of the senses. Observation is something, which the students perform at regular intervals, rather than something, which the teacher does for the students.

By observing the graph one may be able to locate the points. Also through observation identification of different types of angles, prisms, pyramids and other geometrical figures are possible. This operation leads to comparison, classification, inferences, etc.

Coding:

Mathematics is unique for its language and symbolism. So its study can be made easy through the operation of coding. Coding focus on increasing of the students' awareness of the relationship between thinking and writing. For example, instead of saying that the square of the sum of two terms is equal to the sum of the square of the first term, square of the second term and double the product of

the terms, we can simply write $(a+b)^2 = a^2+b^2+2ab$. Coding is the operation of thinking which helps to assign symbols for objects and ideas. Some of the important symbols are : greater than(>); less than (<); angle ($\angle$); parallel lines ($||$); congruence ($\cong$); similar ($\sim$), etc.

Inference and Interpretation:

The operation of interpreting is concerned with the inferences and generalizations, which may be drawn from observation. Interpreting is to add meaning, to read between the lines, to fill in gaps, and to extend on given material within the limits of that material. To interpret is to understand and report, numerical, pictorial, graphic, etc.

Inferences are statements that are based upon observation but include more than observation themselves. They go beyond information and are extensions of observations and serve to summarize, explain or make predictions. It is an ability to make judgments about the non-observable properties of an object or event.

For example, to find the relationship between the number of sides of a polygon and the sum of its angles. For a triangle, sum of the angles is 180^0 for a quadrilateral it is 360^0, for a pentagon it is 540^0. From this the child draws the inference that sum of the angles in a polygon is (n-2) 180 when 'n' is the side of the polygon.

Application:

Application is the ability to apply facts and principles in situations, which are new to us. We have learned in one context and we are now being tested to see if we can make use of what we have learned in another–context. This involves seeing relationships, noticing what "belongs together" in this new context, discriminating what is relevant from what is irrelevant.

Something a situation is described, and a student is asked to predict what will happen in the given circumstances and what is the reason. It requires thought seeing the relevance of principles in a new situation.

For example, a data is given as follows: Container 'X' is 2 inches long, 4 inches wide, 3 inches deep. Container 'Y' is 3 inches long, 4 inches wide and 2 inches deep. Students are asked to determine which of the two containers is the larger Here they have to apply the knowledge about volume and the formula for calculating the volume.

Problem-solving:

In the operation problem-solving, students are given practice in collecting and organizing data. It involves, the activities like sensing the problem, analyzing the situation, organizing information, forming solutions, elimination and verification (Raths, *et al.* 1967).

Some problems require application of principles. Sometimes the solution itself is presented and there is an attempt to see how it was

arrived at. For example, the sum and difference of two numbers are 20 and 15 respectively find the numbers. This problem will motivate the students to review the solution of simultaneous equations in two variables.

The thinking operations, especially the solving of an original problem in mathematics, results in the enjoyment of the child The feeling of mastery, the feeling of self-confidence that one enjoys after the discovery of the solution of a difficult problem is both moral and an intellectual quality extremely desirable from the point of view of training the pupils to think. It is an incentive for further thinking. If we shut out pupils from mathematics we prevent them from exercising their native impulse to think and enjoy successful thinking. It will result in mental apathy. It will encourage pupils to depend more upon authority and tradition than on their own thinking.

Comparing:

It is the simplest way for a teacher to stimulate thinking. To ask the students, to compare things to discern likeness and differences. Discernment may be understood as the acquisition of standards, which in turn results from exposure and exploration. As opportunities for comparison are increased, the bases for judgment are broadened. (Raths, *et al.* 1967). Examples are comparison of different number systems, different types of graphs, geometrical figures, etc.

Classification:

It can be conceived as an extension of comparing in which one looks for similarities and differences. When enough similarities are found, grouping is possible. Grouping themselves may be compared and put into even larger systems. Through this operation students will learn that grouping is possible on several levels with varying degrees of precision. For example, a set of number can be classified into different ways like, natural numbers, integers, even or odd numbers, prime and nonprime, cardinal and ordinal, rational and irrational, etc.

Imagining and Creating:

This operation includes the activities like guessing, intuiting, creating. Imagining and creating activities, be an extension of an existing curriculum an adaptation of present subject matter to accommodate a shift in emphasis. For example, using one of the art forms express a formula, rules or law in science and mathematics. Find some analogies, which will illustrate a particular concept in mathematics or in any other subject.

Summarizing:

Summarizing is more than putting together a series of steps, or recounting and reporting what has taken place. It is to discern and to evaluate what is significant and what is insignificant (Raths, *et al.* 1967).

Titling, inventing captions, organizing data are forms of summarizing. For example, a picture, diagram, chart or graph is displayed and children asked to solicit the titles. Also, students may be working on a problem or attempting to apply principles to new situations. After they have concluded, work on the problem, they summarize the series of steps that they have taken towards the solution.

1.7.3 Importance of Thinking Skills

Most countries are currently concerned with raising educational standards throughout the compulsory school years. But it is also argued as the OECD (Maclure and Davis, 1989) points out, that the minimal requirement of schooling, i.e., mastery of the 'basics' (reading, writing, mathematics, science) however excellently taught, are not sufficient to meet the demand of the labour market and active citizenship. It is now recognized that a broader range of competencies, redefined as 'higher order' thinking skills, is required because :

- The 'banking theory' of knowledge based upon rote learning has been discredited as it is recognized that individual cannot 'store' sufficient knowledge in their memories for future use.

- Information is expanding at such a rate that individual require transferable skills to allow them to address different problems in different contexts at different times throughout their life.

- The complexity of modern job requires staff who demonstrate comprehension and judgment as

participants in the generation of new knowledge of processes.

- Modern society assumes active citizenship, which requires individuals to assimilate information from multiple sources, determine its veracity and make judgment.

- Collectively, these present, a new challenge to develop educational programmes that assume that all individuals, not just an elite, can become competent thinkers because these competencies are now required for all. The cognitive approach suggests that learners must develop an awareness of themselves as thinkers and learners and practice the approaches and strategies for effective thinking.

People see value for both learners and teachers in developing thinking skills and they believe that the process would help children/young people in various ways: thinking skills help learners to consider issues from others point of view, value other people's opinions, respect others, recognize differences, be motivated to learn and enjoy learning, raise their confidence/self-esteem liberate their thinking from constraints of always looking for correct answers to problems, recognize the importance of team work, be more aware of how they prefer to learn, prepare for life after school and for citizenship. While the benefits for teachers include: helping them to recognize different learning styles and reflect more on teaching and learning, increasing their own motivation, making teaching more on teaching and learning, increasing their own motivation, making

teaching more exciting and engaging, cutting down on discipline problems because children enjoy the activities raising teachers' self-esteem because it is obvious pupils are enjoying learning.

1.7.4 Teaching for Thinking

Can thinking skills be taught? All human beings except those who have sustained specific injury or suffer from certain disabilities demonstrate that they can think. Though this question overwhelm many people, however, many qualified their support by pointing out the need to embed specific approaches within an overall teaching and learning strategy at school level. Many believed that thinking skills were already implicit in the curriculum and that many teachers were teaching them within different curriculum areas. People did, however, recognize that it was difficult to distinguish between benefits from teaching thinking skills and those, which resulted from teachers' personal enthusiasm to motivate children.

Thinking skills cannot be divorced from the development of positive values and attributes.

- Effective learning has a social dimension learning from and with others.

- Effective learners need motivation, confidence, resilience, concentration, stamina and they will to keep on learning.

- The effects of learning arguably should benefit not only the learners but can be applied to allow participation as

citizens for the greater good socially, politically, economically, culturally.

Thinking skills will not provide these features. They may facilitate, but will not necessarily ensure important ingredients of education such as initiative, enterprise, flair, imagination, and creativity. The approaches adopted by Nisbet (1993) and McGuinness (1999) are specifically designed programmes infused across the curriculum embedded in a particular subject. Both are problematic. If teachers choose to use one of the many commercially produced specific thinking skills programmes, then they very quickly encounter difficulties of transference. How can they ensure that their pupils/students can apply skills learnt in one context to other situations? Alternatively, if teaching for thinking is embedded in a particular curriculum area, there is no guarantee that learners can isolate it from its context and apply it more generally to other situations. This is a dilemma, which we need to explore today.

Thinking and learning are essentially social. Any attempt to reduce them to a set of specific teachable skills who would run the risk of artificially focusing on one fragment of a holistic process; this would not be conducive to effective learning. Teaching thinking skills remained an issue to be resolved although most thought that it was possible to teach thinking skills. A few notes of caution were sounded. These included the need:

- to distinguish between teaching thinking skills and learning thinking skills. People believe that although they could teach thinking skills, there was inadequate evidence to show that children had actually learnt them.

- to bear in mind individual learning techniques when determining teaching approaches, even for thinking skills.

- to remember that using computers which may provide initial support for teaching thinking skills should be accompanied by opportunities for pupils to apply the techniques learnt and demonstrate their transference to other areas.

The view that thinking cannot be taught directly is now beginning to change as experience and research showed that thinking skills can be taught directly. Accordingly Rath's *et al.* (1967) emphasized that opportunities to think contributes to the process of developing thoughtful inquiry. They define thinking skills, in the form of comparison, classification, observation, coding, interpretation, summarization, and application of facts provides favourable situations for elicit thinking of the participants. The most significant hypothesis derived from their theory suggests that as students engage in these thinking skills regularly and consistently, the behaviours indicative of immaturity tend to decline.

1.8 Need for Development of Thinking Skills

Thinking takes place in the form of images, concepts, signs and symbols, language, muscle activity and over all it is important

function of the brain, of all different kinds of thinking, i.e., concrete thinking, abstract thinking, reflective thinking and creative thinking. One does not stop to think. The second illustration is reflected in the characterization that a student does not concentrate, at some moment in time he is not paying attention to what he is doing and hence meets failure in his work. It is commonly assumed that this is a neglect of rigour in the thinking processes. Where there is an emphasis upon thinking in the curriculum students tends to modify their behaviour, where there is frequent opportunity to engage in a great variety of processes, which involve thinking the frequency of impulsive behaviour, tends to decline. It is important to note that we are not suggesting that teachers can or should teach children how to think. There is no "one way" of thinking; we tend to assume that in the normal population of the human family the capacity to think and the opportunities to discuss the thinking, which is done. Inconsistency and incompleteness of thoughts or limited experience with thinking is often reflected in certain kinds of human behaviour, which can be observed in the classroom. Here the thinking is defined, in terms of its ability to explain the behaviour in question.

Children with certain thinking related characteristics may be identified. These children may be given many opportunities over a period of one semester to think and then on assessment of their behaviour can be carried out a second time. Is it reasonable to support that if we are given many opportunities to think we might

become different in our behaviour? There is substantial agreement that an emphasis upon thinking activities will encourage thinking and result in a decrease in what may be termed "immature" behaviour. A theory that is worth its salt tends to grow out of observed facts. This theory has developed from classroom observation from long years to work with teachers and from experimental evidence.

The thinking skills represent activities, which involve many kinds of thinking. We are emphasizing opportunities to think and opportunities to share our thinking as inquiry is carried forward in terms of purposes important to these situations. The thinking skills can be used to develop habits of thoughtful inquiry. Are we concerned purely with intellectual processes? We believe that emotional security is very important and a necessary condition in the learning processes associated with school life. The weaning processes carried on in early childhood can explain not all behaviour. We know that thinking enters into many facts of life that man is not compartmentalized that thinking must be thought of in its relationship to values and that values must be looked at in terms of consequences. Young children are not been given many opportunities to think in schools. Children have great capacities for thinking and if thinking is stressed in our schools, there will be increased tendency to use thinking skills in the solutions of many life problems.

Almost all the subjects in the present curriculum give emphasis to the process of thinking. Thinking is no doubt an essential

commodity for all of us. Fostering thinking skills has always been the prime objective of formal education, a basic aim of teaching and learning in all discipline. Every education system in the world will tend to claim that it already fosters thinking skills. The term thinking embraces a wide range of cerebral activities. It involves problem-solving, decision making, logical reasoning, critical thinking, reflective thinking, inferential thinking and even creative thinking (Nickerson, 1988) It refers to a range of skills such as choice making, deliberate planning, flexibility, looking into alternatives, solving problems systematically, taking initiative, reducing impulsivity, persistence, considering others points of view, supporting conclusion with evidence, risk taking, meta cognition, empathy and so on. These skills are considered essential to make the best use of existing knowledge and to gain further knowledge and facilitate learning to learn.

The lack of emphasis on thinking in a system is associated with the work and attention that are involved. Where thinking is stressed, the teacher must necessarily supplement the existing texts by exercises, which call for thinking. If children are allowed to think, indeed are encouraged to think, perhaps they will think something that they can't. It also suggests that day-by-day we are zealous in our efforts to create a free society. It may also imply that we are afraid to face up to the consequences of thinking. Our neglect of thinking processes in our schools may be associated with a lack of skill and appreciation on the part of teachers. If teachers are not well prepared

by their own education to put an emphasis on thinking, one can understand the neglect of thinking skills in the lives of the school children.

Thinking has to be necessarily personal and creative. It cannot be recreative and reproductive As Dewey has said so well, thoughts and ideas cannot possibly be conveyed from one mind to another, only facts can be transferred For teachers to provide opportunities for thinking would be to advance citizenship education. What is needed are many examples at the grass root level. If thinking processes are to be nurtured, an awareness of attitudes and tactics, which inhibit thought, on the one hand and on the other, those which promote thought need to be developed

In the textbooks the materials are made available in a ready-made form, which goes against thinking. These books do not lay stress on understanding with the present day method of teaching and criteria of judgment of progress. The pupils form misleading notices about their intelligence. This will result in a lack of confidence, nervousness and confusion, which hinders the mental abilities, such as, power of thinking and concentration, and get disgusted to study and to do routine work in the school.

The need for emphasizing thinking in the schools and colleges is felt, because there is a gradual shift in the focus of education from learning to thinking. Children have to think for themselves, not only

to learn what has been taught but also to make good judgments Since acquiring thinking skills and habits is generally believed to be learned over a long period of time, it would logically follow that thinking needs to be taught throughout the educational program as it enhances the quality of education that the child receives in school. Thinking has to be developed in earlier age of child where teacher play a very important role. School provides an environment, which can foster thinking skills in the pupils.

In the twenty first century, we want citizens who can think and make verbal decisions, which will be useful in the life for a good democratic society We want our children to think, reflect upon their thinking, think upon what they are thinking, and think independently to develop intellectual humility and suspended judgment, develop intellectual courage, good faith and apply the knowledge precisely. Without thinking, people would be more easily exploited not only politically but also economically.

CHAPTER - II

REVIEW OF RELATED LITERATURE

In order to build a better perspective of the study the books, research journals, handbooks on surveys, theses, abstracts, encyclopedia, internet are reviewed and presented in this chapter.

The research studies related to the present study are presented under the following headings :

- Studies related to thinking operations in mathematics;
- Studies related to factors affecting thinking operations in mathematics;
- Studies related to gender;
- Studies related to social status;
- Studies related to attitude towards mathematics; and
- Related studies on thinking operations and achievement in mathematics.

2.1 Studies Related to Thinking Operations in Mathematics

The study of mathematics helps one to develop all the intellectual powers like power of imagination, memorization, observation, invention, concentration, logical thinking and reasoning. The conventional method of teaching of mathematics had no effect in the development of these mental faculties. The focus on cognitive process has become more prominent place in mathematics education. **Wittrock, M.C.** (1974) was one of the first to point out the broad

implications of the developing field of cognitive sciences for research in mathematics education.

Now-a-days new models and techniques of teaching are evolved in the development of thinking skills in mathematics such as advance organizer mode, inquiry training model, etc. Even though thinking operations have an inevitable place in the cognitive development as well as achievement, the investigator failed to locate any research on thinking operations in mathematics. Some research findings related to thinking operations in mathematics are reviewed here.

Basu, A.K. (1969) conducted study on the construction and standardization of group test of Problem solvingability in arithmetic. The sample consisted of 982 pupils of class VIII being drawn from twenty-six schools from all areas of Calcutta. The study showed that the boys were superior to the girls in respect of problem ability.

Verma, R.S. (1973) conducted the study on a factor analytic study of divergent thinking on relation to certain personality dimensions of higher secondary school adolescents. The sample consisted of 640 students. The study showed that the effect of divergent thinking on ego strength was little and autonomy, nonconformity and openness of mind could help in understanding the divergent thinking of adolescents by regarding them as potentially creative persons and differentiating them from non-potential creative persons.

Gurbaksh, L. (1974) conducted a study of relationship between creative thinking and vocational anxiety and their effect on success in teaching. The sample consisted of 300 teacher trainees studying in three colleges of Punjab. The study showed that interaction effect of vocational anxiety and creative thinking on teaching success was found to be significant whereas interaction effect of general anxiety and creating thinking on teaching success was found to be not significant and *it was concluded that the vocational anxiety and general anxiety were two separate psychologically meaningful entities and not reducible one*

Vaidya, N. (1974) conducted the study of some aspects of thinking among science students of adolescent age. The sample of the study comprised 100 boys and 100 girls of the age group 10 to 15 years, selected from the grades VI through X on the basis of intelligence and S.E.S. in Rajasthan. He found that unsuccessful problem followers were highly districtable, showed poor concentration and were little interested in schoolwork.

Pillay, G.S. (1978) conducted the study on effects of patterns of teaching upon creative thinking among adolescents. The sample consisted of 71 eighth grade students. The findings showed that the convergent production ability in geography of eighth graders improved significantly by creative thinking method than by the traditional method.

Bala, V. (1980) studied "the effects of modern and traditional mathematics curricula on Piagetian concrete and formal logical thinking. The sample consisted of 58 students of Grade IV, and 60 of Grade VII, selected from a school in Ambala. The findings showed that modern mathematics facilitated Piagetian cognitive thinking ability to a greater degree than the traditional mathematics at the primary school level.

Dagaur, B.S. (1982) conducted the study of relationship between anxiety and creative thinking. The sample consisted of 762 subjects of class XI from twelve senior secondary schools. The findings showed that males and females did not differ as regards creative thinking abilities and anxiety, extraversion and neuroticism were normally distributed. *There was high positive relationship between anxiety and neuroticism and between psychoticism and anxiety*

Douglas, H. (1983) studied the effects of two training sequences on the development of young children's logical operations and number concepts, including rational counting strategies, were investigated. Forty-five preschool children, aged 3.11 to 4.10, were randomly assigned to two treatment groups and one control group. Subjects in the treatment groups received training either in classification and seriation skills (logical foundations) or in rational counting strategies and other number skills (skills integration). The control group

children received instruction devoid of logical/mathematical content. Major pretest and posttest findings indicated that while both experimental groups significantly outperformed the control group on number concepts and logical operations tests, the number skills integration group significantly outperformed the logical foundations group on the number concepts test.

Haq, A. (1984) conducted investigation on the convergent thinking of VIII Standard students and their performance on the process based text. The study was conducted on the sample of 190 students including 100 girls and 90 boys. The study added to the evidence that the gender difference existed in the performance of process based text.

Handrickson, A.D. (1986) provides examples of 'if-then' and combinatorial reasoning situations that have proved successful with college students and can be used with secondary school students. Proposes that practice with these problem-solving processes can eliminate the need to memorize formulae that students may not understand.

McGarvey, L.J. *et al.*(1989) constructed the underlying simple paper-and-pencil logical operations tasks administered to young children in group settings was examined. The logical operations, number concepts, and visual discrimination subtests of the Early School Assessment (ESA) were administered as part of the Fail 1987

national tryout of the ESA. The mathematics concepts and applications subtest of the California Achievement Test (Form E) was administered as an anchor. The two subtests of ESA Level 1 was administered to 766 and 1,456 beginning kindergarten students and the three subtests of ESA Level 2 was administered to groups of 1,553, 1,728, and 888 first graders. It was hypothesized that the logical operations items in the ESA could be aligned with either visual discrimination tasks or with mathematics. An item analysis was conducted. All three ESA subtests were highly correlated with the mathematics test. The analysis revealed that these paper and-pencil logical operations items were more closely related to number concepts than to visual discrimination, but they were distinct. These paper-and-pencil operations were not highly correlated with more traditional tasks involving manipulatives, suggesting that different constructs were being measured. The mode of response is a critical issue in the assessment of logical operations in young children; this issue raises questions of construct validity. Six tables present study data.

Berenson, S.B. *et al.* (1990) assessed the level of thinking of 140 students who had been placed in developmental algebra as entering college freshmen. Scores on the group assessment of Logical Thinking, Scholastic Aptitude Tests, college placement tests; high school grade point average, and developmental algebra final grade were analyzed. Group characteristics are presented.

Bitner, B.L. (1990) investigated the effect of an eclectic thinking processes model on the logical reasoning abilities of students in grades six through twelve. The experimental school consisted of 159 students whereas the control school had 111 students. The Group Assessment of Logical Thinking (GALT) was administered to the sample as a post-test. The thinking processes model incorporated logical, critical, and creative thinking skills. Teachers in the experimental school were presented with the model during workshops in the summers of 1986 and 1987. These teachers were encouraged to infuse the thinking process into the mandated curricula during the 1986-1987 school term and were expected to do so in the fall of 1987. The control district neither participated in the two summer workshops nor were expected to infuse thinking processes into the mandated curricula. For both the experimental and the control school, correlational reasoning followed by probabilistic reasoning was the most difficult. The experimental school performed significantly higher than the control in controlling variables, correlational reasoning, and the total GALT score Classification of the students according to reasoning levels revealed that only 3% of the total sample performed at the formal operational reasoning level. The significant differences favoring the experimental school seemed to indicate that the eclectic thinking processes model was effective.

Bitner, B.L. (1991) studied the five formal operational reasoning modes in the Group Assessment of Logical Thinking were found to be

statistically significant predicators of critical thinking abilities as measured by the Watson Glaser Critical Thinking Appraisal and were significant predictors of science and mathematics grades.

Saayman, R. (1991) discussed the structure and results of a university physics entry examination that measures students' expertise with mathematical tools and formal logic operations required for the study of college physics. The study indicates that the examination adequately serves incoming students' to evaluate academic potential, to emphasize specific deficiencies; and to recommend choices for course of study.

Joan, E. *et al* (1992) examined social and cognitive play behaviours of preschool children in comparison to tests of convergent and divergent thinking. High level on non social activity was associated with low scores on the convergent thinking measure. There were negative relationships between non social play and divergent thinking.

Nasser, R. *et al* (1991) studied whether students perform differently on algebra word problems that have certain key context features and entail proportional reasoning relative to their level of logical reasoning and their degree of field dependence/independence. Field-independent students tend to restructure and break stimuli into parts and to perceive details more readily than field-dependent students. The underlying theoretical view is that context may be an

important factor in how students approach, analyze, and restructure word problems. The sample included university students (n=37) and secondary school students (n=193) from two large high schools in two cities. The Gottschaldt Hidden Figures Test was used to assess field dependence/independence. Selected items from the Equilibrium Balance Test were used to assess Piagetian stages of logical reasoning. A 2 X 3 MANOVA was used to analyze the effects of cognitive style (dependence, independence) and operativity (concrete, transitional, formal). Overall, field independent subjects who were formal operational reasoners performed highest across all the problem features. The result supported the influence of cognitive style, together with cognitive development in mediating a student's ability to solve algebra word problems.

John, S. *et al.* (1993) conducted a study on integration of mathematics, science and technology of education as basis for thinking and problem solving. The sample consisted of 148 students. The findings showed that there is higher order learning in a multi-disciplinary project.

Howard, T. and **Sonia, J.** (1994) conducted a project on Mathematical Thinking Skills. The study consisted of 314 students aged between 11 and 13. Findings of the study showed that intervention students performed significantly better than control students in both cognitive and metacognitive posttests.

Berg, C.A. *et al.* (1994) using Piagetian tasks they designed to assess specific mental structures. Researchers investigated the relationship between logical thinking structures and the ability of students to construct and interpret line graphs. Results revealed that a significant correlation exists between the afore mentioned variables. It was found that only at certain cognitive developmental levels can students be expected to develop and understand line graphs.

Bigler, R.S. (1995) investigated the effect of using gender as a functional category in elementary school students' gender stereo typing. Results supported the idea that the functional use of gender categories leads to increase in gender stereo typing, particularly among these children with less advanced classification skills. Advanced classification skills proved to moderate these societal influences.

Suja, S.P. (1995) conducted a study on the influence of examination anxiety and intelligence on Problem solvingability of secondary school students in mathematics. The sample of the study consisted of 570 students of IX Standard of Kottayam District. She found that anxiety and intelligence on Problem-solvingabilities are negatively and significantly correlated.

Van, D.F. (1995) provided a teacher's guide and activity sheets designed to introduce students to three patterns of reasoning in inferential logic. Students learn to construct arguments from

diagrams and, given an argument, illustrate the argument with a Venn diagram, and then study the diagram to see if the argument is valid or invalid.

Latha, E.K. (1996) conducted a survey to find to Geography Thinking Operation of the Pupil of Selected High Schools of Kasargod Taluka of 450 pupils of Standard VIII. It was revealed that these thinking operations are not equally distributed.

Oers, B.V. (1996) investigated which teaching opportunities within a role play activity could be considered valuable for the improvement of mathematical thinking. Observations indicated many such opportunities, suggesting that if teachers manage to make use of such teaching opportunities, children can explicitly reflect on the relationship between symbols and meanings within play activities.

Koyama, M. (1997) identified students' mental models of an abstract mathematical concept regarding intuition. Observed how students think reflectively on their mental models in a whole-class discussion in terms of logical thinking.

Donga, N.S. and **Molia, M.S.** (1998) conducted an experimental study on the effect of meta cognitive process on learning process in mathematics. Sample of the study was 66 students of Standard IX. The results of the study pointed out that the learning process used by the group taught through meta cognitive process programme is better

than that used by the group taught through conventional teaching programme.

Krupa, G.A. (1998) in her study of thinking operations in physics and the factors affecting it of the secondary school students on a sample of 700 of IX Standard students of Kottayam district showed that the thinking operations do not distribute equally at different levels of distribution

Kochurani, K.G. (1999) conducted a study of thinking operations in mathematics and related factors of the students of IX Standard of Kottayam district. The study consisted of 500 students. Findings of the study showed that there was no significant difference in thinking operations of the students

Patil, S.P. (2001) conducted a study on relative effectiveness of different logical thinking operations on achievement in mathematics. The sample of the study consisted of 250 IX Standard students of Dharwad taluka. He found that students with favourable and unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operations.

Shoba, D. (2001) conducted study on the effect of the self-designed instructional material on the selected thinking skills. The sample consisted of 292 pupils selected from VIII Standard of Kannada medium Government high schools. The findings showed the

significant effect of self designed instructional material on the selected thinking skills.

In the above studies, different aspects related to thinking operations in mathematics were discussed. Basu, A.K. (1969), Vaidya, N. (1974), Handrickson, A.D. (1986), John, S. *et al* (1993), Nasser, R *et al.* (1993), Howard, T. *et al* (1994), Bery, C.A. *et al.* (1994), Van, D.F. (1995), Supa S.P. (1995), Oers, B.V. (1996), Koyama, M. (1997), Donga, N.S *et al.* (1998), Bala, V. (1980) and Douglas, H. (1983) have studied about metacognitive process in mathematics (problem solving abilities). Verma, R.S. (1973) conducted a study on divergent thinking and Haq, A. (1984) and Joan, E. *et al.* (1992) studied on convergent thinking. The relationship between anxiety and creative thinking was studied by Gurbaksh, L. (1974) and Dagaur, B.S. (1982). Also Pallay, G.S. (1978) showed that convergent production ability in geography of VIII graders improved significantly by creative thinking method than by the traditional method. McGarvey, L.T. *et al.* (1989), Saayman, R. (1991), Berenson, S.B. *et al.* (1990), Bitner, B.L. (1990), Kochurani, K.G. (1999) and Patil, S.P. (2001) have conducted a study of logical thinking operations in mathematics. Thinking operations other than the mathematics was investigated by Latha, E.K. (1996) and Krupa, G.A. (1998) in geography and physics respectively. Lastly, Shoba, D. (2001) conducted a study on effect of self-designed instructional material on the selected thinking skills and she showed that there was

a significant effect of the self-designed instructional material on the selected thinking skills. Hence, in the present study, it was decided to investigate the thinking operations in mathematics among the students of secondary schools.

2.2 Studies Related to Factors Affecting Thinking Operations in Mathematics

Thinking is a process developing through different stages. Education is the process for development and improvement of the power of thinking. The process of thinking gets success only if the teacher has complete knowledge of his subject. (**Maria Kein** *et al*)

Even though intellectual abilities are inherited, there exist some factors affecting the development of intelligence. These are the intellectual atmosphere at home, the socio economic status of the parents, the emotional atmosphere in the home and the kind of education available to the child, including the types of school and medium of instruction, etc. Sometimes the gender difference also has effects on the normality of the thinking skills.

Thinking is also affected by attitudes, prejudices and beliefs. Attitudes are generalized dispositions for certain particular ideas, things or persons. Unless a student has a favourable attitude towards subject of the study he/she may not achieve considerably in that subject and may not also like to study it at higher levels. The child's attitude towards the teacher, the method of teaching, the text book, the subject itself, will affect the thinking skills. Hence, the

investigator felt the need to take the above-mentioned variables for the present study.

The studies related to different variables are given below :

Raven, R.J. (1987) compared the differences in ratio construction of high school freshman and junior students. The study reports that more freshmen than juniors selected solutions involving one variable, whereas juniors chose solutions that coordinated two variables in a mathematical or verbal rule.

Silver, E.A. (1996) studied mathematical problems generated by 509 middle school students who were given story problem descriptions and asked to pose questions that could be answered using the information were examined for solvability, linguistic and mathematical complexity, and relationships within the sets of posed problems. Teachers evaluating students' posing of arithmetic story problems can implement the multiple step data analysis scheme.

Cerrito, P.B. (1996) in his paper argues that separation of mathematics from most other disciplines in the college curriculum reinforces math avoidance among college students, and that this is inappropriate in general education. Ways in which mathematics and mathematical thinking can be integrated into the humanities are discussed, including the role of mathematics in history, developing precision in language use, and logical thinking.

Goral, C. M. (2002) studied the interactive effect of sex, caste and attitude towards mathematics on different logical thinking operations in mathematics like observation, coding, inference, application and problem solving. The sample consisted of 303 students studying in IX Standard. 3 way ANOVA was used to find out the difference in the effects of independent variables. It was found that favourable and unfavourable attitude towards mathematics influenced on thinking operations like coding and application. Sex and caste; sex and attitude; and caste and attitude taken two factors each time jointly influenced upon logical thinking operation like coding. Further, the interaction among all the three selected factors had influenced upon logical thinking operations like coding and application

2.3 Studies Related to Gender

The effect of gender on Problem solvingability was studied by **Basu, A.K.** (1969). The findings showed that the boys were superior to the girls in respect of Problem-solvingability.

The results of the survey on women in mathematics by **Armstrong, N.A.** (1982) indicated that girls were better at spatial visualization and computation than were boys, while Problem-solvingskills were equal.

Peterson, P.L. and **Elizabeth** (1985) conducted a study on effective teaching student engagement in classroom activities and sex

related differences in learning mathematics of 36 IV grade teachers and their Mathematics classes in 15 schools located in the rural areas. The study showed that boys and girls did not differ significantly in their achievement.

Jai, S. J. (1987) compared the students sexwise in their level of convergence. The subjects of the study consisted of 654 students of arts and science subjects enrolled at colleges. In the comparison between the sexes both male and female students showed almost identical performance on convergence.

Kulshreta, A. and **Jain, S. C.** (1989) studied the relationship between the classification skill and the gender difference of pupil. The sample of the study consisted of 20 boys and 20 girls of VI, VII, and VIII Standards. The study led to the conclusion that the overall performance of the girls on classification skill was better than the performance of the boys.

Herbert, M.N. (1989) conducted a study on sex difference in the development of verbal and mathematical constructs of the high school students and beyond. It was found that determinants of the verbal and mathematical constructs were similar to boys and girls.

Battista, M.T. (1990) investigated gender differences and the role of spatial visualization in Problem-solving in high school geometry. The study reports that, while males and females differed in spatial visualization and in their performance, they did not differ in

logical reasoning ability or in their use of geometric problem-solving strategies.

Suja, S.P. (1995) studied the effect of gender on Problem-solvingability. The study showed that there exists no gender difference in the Problem solvingability.

The third International Mathematics and Science study conducted by **Beaton, A.E.** *et al.* (1996) on more than a half million students of five grade levels of 41 countries showed that gender differences in mathematics achievement were small or nearly non-existent in most countries.

Latha, E.K. (1996) found the difference between boys and girls in thinking operations in geography. The findings revealed that boys were higher than girls in thinking operations.

In a study of identification of selected cognitive affective variables as predictors of mathematics achievement of secondary school pupils by **Sajikumar, A.** (1996) found that there was no difference between boys and girls in terms of intelligence.

Krupa, G.A. (1998) showed that girls are higher than boys in thinking operations in physics.

Kochurani, K.G. (1999) tried to find out the difference between boys and girls on thinking operations in mathematics. The findings

revealed that there was no significant difference in the thinking operations between boys and girls.

Patil, S.P. (2001) showed that there exists no gender difference in logical thinking operations on related to achievement in mathematics

From the above studies the following conclusions could be drawn : The studies conducted by Peterson, P.L. and Elizabeth (1985), Jai, S.J. (1987) on gender difference showed that boys and girls do not differ significantly in their cognitive abilities. Studies of Herbet, M.N. (1989), Suja, S.P. (1995), Baton, A.E. *et al.* (1996), Sajikumar, A. (1996), Kochurani, K.G. (1999) and Patil, S.P. (2001) found that there exists no significant difference in the thinking skills. But Basu, A.K. (1969), Armstrong, N.A. (1982) and Latha, E.K. (1996) have shown in their studies that thinking operations of boys are higher than that of girls. The third category of studies showed that thinking operations of girls were higher than that of boys by Kulshreta, A. and Jain, S.C. (1989), Krupa, G.A. (1998). But Bittista, M.T. (1990) showed that males and females differed in spatial visualization and in their performance, they did not differ in logical reasoning ability or in their use of geometric Problem-solvingstrategies. Thus, the acquisition of cognitive level operations by boys and girls seems to be varied in the results. Some studies favour the boys, and some other studies favour the girls, while some studies showed no significant difference between boys and girls. Hence, the investigator formulated a null hypothesis

to test the significant relationship between thinking operations and gender difference.

2.4 Studies Related to Social Status

Mihir Kumar, C. (1998) conducted a quasi-experimental study on educational backwardness of scheduled caste students in West Bengal. The sample consisted of a group of 400 SC students and equal number of other students. The research finding was that the academic achievement of SC secondary school students was significantly poorer than that of the other students

Kochurani, K. G. (1999) conducted a comparison of different thinking operations among scheduled caste and non-scheduled caste students. The study showed that non-scheduled caste students were better in the acquisition of thinking operations in mathematics than the scheduled caste students.

Thus, the research findings showed that the academic achievement and thinking operations of scheduled caste students were significantly poorer than that of the other students.

Since there was no study available regarding the selected variables in the present study, the investigator had to formulate the null hypothesis to test the significance of the difference between scheduled caste students and others in thinking operation in mathematics.

2.5 Studies Related to Attitude towards Mathematics

Sing, D. R. *et al.* (1994) conducted a study on the attitude of high school students towards mathematics. The findings indicated that the attitude is related to intelligence. The intellectual superior students have more favourable attitude towards mathematics in comparison with intellectually inferior students. The study on the influence of study habits and attitude on achievement in mathematics by **Susan, P.** (1996) showed that there exists no significant relationship between attitude and achievement in mathematics. **Antonio, N.** *et al.* (1997) conducted a study on Problem solving in physics. The sample consisted of students of 16 years of age in physics at two Portuguese high schools. The study showed that there exists a less significant relationship between cognitive abilities and attitudes.

A study on the relationship between attitude towards mathematics and thinking operations in mathematics of IX Standard students of Kottayam district by **Kochurani, K. G.** (1999) showed that there exists a significant relationship between attitude towards mathematics and thinking operations in mathematics.

The attitude is related to intelligence according to Sing, D.R. *et al.* (1994). Susan, P. (1996) showed no significant relationship between attitude and achievement in mathematics. But Antonio, N. *et al.* (1997) and Kochurani, K.G. (1999) showed the significant relationship between attitude towards mathematics and thinking

operations in mathematics. Thus, the studies conducted so far revealed contradictory findings. Therefore, the investigator formulated a null hypothesis to find out the relationship between thinking operations and attitude towards mathematics.

2.6 Studies Related to Thinking Operations and Academic Achievement in Mathematics

Education brings about changes in individual's cognitive, affective and psychomotor domains. When the changes in these domains lead to development in desirable directions, the individual achieves knowledge, acquires skills and attains worthy attitudes.

Low achievement in school mathematics has become a problem in our country. The blame is on the teachers or on the pupils. But Mathematical ability responsible for low achievement is a matter of primary concern (**Rastogi, S.** 1986)

Mathematics is a subject, which totally banks upon the intellectual and mental capacities. The inadequacies in mental abilities such as thinking, reasoning, power of concentration, memory are the probable cause of low achievement in mathematics. It is the teacher's role to develop mathematical abilities in the students through his/her thought provoking teaching. If the meaningful learning takes place in mathematics, the person of even low intelligence can also understand mathematics better. Hence, in the present study thinking operations and academic achievement are correlated. Studies regarding the relationship between thinking

operations and achievement in mathematics are reviewed in this section :

Latha, E. K. (1996) studied the relationship between thinking operations and achievement. The study showed that there exists a positive significant relationship between thinking operations and achievement in social sciences.

Michael, S. (1996) conducted a study on the long term effect of cognitive acceleration on pupils' school Achievement. Sample of the study consisted of 4500 pupils. The findings of the study showed that there is a relative order of increase in achievement in mathematics with thinking skills

Suji Kumar, A. (1996) conducted a study on relationship between intelligence and achievement. The study showed that there exists a positive significant relationship between intelligence and achievement in mathematics.

Jyothi, C. (1997) showed that there exists a significant relationship between creativity and achievement in mathematics.

Fuchs, L. S. *et al.* (1998) conducted an experimental study on high achieving students' interactions and performance on complex mathematical tasks as a function of homogeneous and heterogeneous pairings. The results showed that high achievers generated better

mathematical performances with their high achieving classmates than with their lower achieving peers.

Krupa, G. A. (1998) had also shown that thinking operations and achievement in physics were positively and significantly correlated

Kochurani, K. G. (1999) showed that the thinking operations in mathematics of IX Standard students were positively related to their achievement in mathematics.

Patil, S. P. (2001) showed that the effect logical thinking operations on the academic achievement in mathematics are more in girls than in boys.

Nayak, G. T. (2002) studied the effect of logical thinking operations on academic achievement in mathematics. Observation, coding, inference, application and Problem solvingare the thinking operations considered in the study. The study covered 303 students studying in IX Standard in ten secondary schools of Kalghatagi taluka. Pearson's product-moment correlations, multiple-regression analysis, path analysis and principle component factor analysis were used to analyse the data. The study revealed that thinking operations like coding, inference, application and Problem-solvingare having positive and significant relationship with achievement in mathematics. The operation coding seems to be the best predictor of achievement of mathematics. In the order of priority, the next predictors are

inference, application and problem solving. The thinking operations like coding and inference have significant direct effect on achievement in mathematics. Lastly, the thinking operations inference and application are clustered under a single group with high factor loading

By analyzing the above studies it can be concluded that cognitive abilities have positive influence on the academic achievement [Sajikumar, A 1996; Michael, S. 1996; Jyothi, C. 1997, Fuchs, L. S. 1998). The studies by Latha, E. K. (1996); Krupa, G. A. (1998); Kochurani, K. G. (1999)] showed that achievement in different school subjects is significantly correlated to thinking operations in the respective school subjects. The studies reviewed are not directly related to the thinking operations and achievement in mathematics. Therefore, the investigator formulated a null hypothesis to determine the significant relationship between achievement in mathematics and thinking operations.

CHAPTER – III

THE PROBLEM

3.1 Need for the Study

Results of the national survey and the Ph.D. studies clearly revealed that (i) the performance of our students is far from satisfactory with reference to application questions, and (ii) higher cognitive abilities contribute more in mathematics performance. Further, it is a matter of common experience of teachers teaching mathematics that students by and large do not perform well on application and reasoning questions.

Mathematics reform movement posits an ambitious set of outcome for student learning. Documents published by the National Council of Teachers of Mathematics (1991), the Mathematical Association of America (1991) and the National Research Council (1989) all point to the importance of students' developing deep and interconnected understanding of mathematical concepts, procedures and principles, not simply an ability to memorize formula and apply procedures. Increased emphasis is being placed not only on students' capacity to understand the substance of mathematics but also on their capacity to do mathematics (Mary Kay Stain, *et al*, 1996).

In recent years mathematics educators and philosophers have convincingly argued that full understanding of mathematics consists

of more than knowledge but include the capacity to engage in the process of mathematical thinking.

According to Romberg (1985), students should not view mathematics as a static bounded system of facts, concepts and procedures to be absorbed but rather as a dynamic process of gathering, discovering and creating knowledge in the course of some activity having a purpose. The National Policy of Education (1986) also advocated "a child centered and activity based process of learning". To facilitate this the National Curriculum Framework has visualized a change in the teachers' role from that of a mere transmitter of information to that of a facilitator of learning.

But the teaching for thinking is not fruitful in present days. The teacher clings to traditional methods. Therefore, the power of thinking, understanding and retention are not developed in the students. There is spoon feeding which the student can comfortably swallow and digest. The authorities run after attractive results which are obtained only through cramming. There is no emphasis on thought, understanding, initiative, judicious study and power.

Now-a-days the aim of learning is to get through the examination rather than to understand and grasp the subject. As a result the students' enthusiasm and interest are curbed. Examination is a matter of chance more in mathematics than in any other subjects.

A crammer may get the upper hand in the examination and an intelligent may not get his due.

Hence teacher has to organize the learning situation to stimulate curiosity and independent thinking, develop Problem-solving skills, promote planning and execution of projects and self-learning involving acquisition of knowledge through observation of phenomena, creative thinking activities in the mathematics classroom. Consistent engagement in such thinking practices should in turn, lead to a deeper understanding of mathematics.

Having gone through the present status and importance of thinking in mathematics, the investigator attempted to answer the question, whether the present condition of teaching and learning, the existing curriculum and textbook foster the thinking operation in mathematics of the students of secondary school students. Hence, the study assumes its significance and relevance.

3.2 Statement of the Problem

The present study may be stated as '*A Study of Sequence of Logical Thinking Operations in Mathematics among Disadvantaged Children*'.

3.3 Objectives of the Study

3.3.1 General Objectives

The present study was undertaken with the following objectives in view :

i. To compare the variations in attainment of logical thinking operations in mathematics among children belonging to SC and ST Category ; ST and General Category and SC and General Category.

ii. To study the interaction effects of sex, caste and attitude towards mathematics on attainment of sequence of logical thinking operations in mathematics.

iii. To study the relationship of logical thinking operations with academic achievement in mathematics among SC, ST and General Category students.

iv. To determine the relative efficiency of the logical thinking operations in predicting academic achievement in mathematics among SC, ST and General Category students.

v. To determine the direct and indirect effects/paths of set of logical thinking operations on academic achievement in mathematics among SC, ST and General Category students.

vi. To determine the cluster of logical thinking operations in terms of their contributions to variation in academic achievement in mathematics among SC, ST and General Category students.

3.3.2 Specific Objectives

In pursuance of the General Objective – i, the following specific objectives were setup :

1. To compare the variations in attainment of logical thinking operation – observation among SC and ST, SC and General category, and ST and General category children.

2. To compare the variations in attainment of logical thinking operation – coding among SC and ST, SC and General category, and ST and General category children.

3. To compare the variations in attainment of logical thinking operation – inference among SC and ST, SC and General category, ST and General category children.

4. To compare the variations in attainment of logical thinking operation – application among SC and ST, SC and General category, and ST and General category children.

5. To compare the variations in attainment of logical thinking operation – Problem-solving among SC and ST, SC and General category, and ST and General category children.

In pursuance of the General Objective – ii, the following specific objectives were set up :

6. To study the influence of sex on attainment of five logical thinking operations :
   a. Observation
   b. Coding
   c. Inference
   d Application
   e. Problem-solving

7. To study the influence of caste on attainment of five logical thinking operations :
   a Observation
   b. Coding
   c. Inference
   d. Application
   e. Problem-solving

8. To study the influence of attitude towards mathematics on attainment of five logical thinking operations :
   a. Observation
   b. Coding
   c. Inference
   d. Application
   e. Problem-solving

9. To examine the interaction effects of sex and caste on attainment of five logical thinking operations :
   a. Observation
   b. Coding
   c. Inference
   d. Application
   e. Problem-solving

10. To examine the interaction effects of sex and attitude towards mathematics on attainment of five logical thinking operations :

    a. Observation
    b. Coding
    c. Inference
    d. Application
    e. Problem-solving

11 To examine the interaction effects of caste and attitude towards mathematics on attainment of five logical thinking operations :

    a. Observation
    b. Coding
    c. Inference
    d. Application
    e. Problem-solving

12 To examine the interaction effects of sex, caste and attitude towards mathematics on attainment of five logical thinking operations :

    a. Observation
    b. Coding
    c. Inference
    d. Application
    e. Problem-solving

In pursuance of the General Objective –iii, the following specific objectives were set up :

13. To study the relationship of logical thinking operations – observation, coding, inference, application and Problem-solving with academic achievement in mathematics among SC category students.

14. To study the relationship of logical thinking operations – observation, coding, inference, application and Problem-solving with academic achievement in mathematics among ST category students.

15. To study the relationship of logical thinking operations – observation, coding, inference, application and Problem-solving with academic achievement in mathematics among General category students

In pursuance of the General Objective – iv, the following specific objectives were set up :

16. To determine the relative efficiency of the different logical thinking operations – observation, coding, inference, application and Problem-solving in predicting academic achievement in mathematics among SC category students.

17. To determine the relative efficiency of the different logical thinking operations – observation, coding, inference, application and Problem-solving in predicting academic achievement in mathematics among ST category students.

18 To determine the relative efficiency of the different logical thinking operations – observation, coding, inference, application and Problem-solving in predicting academic achievement in mathematics among General category students.

In pursuance of the General Objective – v, the following specific objectives were set up :

19. To determine the direct and indirect effects of logical thinking operations – observation, coding, inference, application and Problem-solving on academic achievement in mathematics among SC category students.

20. To determine the direct and indirect effects of logical thinking operations – observation, coding, inference, application and Problem-solving on academic achievement in mathematics among ST category students.

21. To determine the direct and indirect effects of logical thinking operations – observation, coding, inference, application and Problem-solving on academic achievement in mathematics among General category students.

In pursuance of the General Objective – vi, the following specific objectives were set up :

22. To determine the cluster of logical thinking operation – observation, coding, inference, application and Problem-solving in terms of their contributions to variation in academic achievement in mathematics among SC category students.

23 To determine the cluster of logical thinking operation – observation, coding, inference, application and Problem-solving in terms of their contributions to variation in academic achievement in mathematics among ST category students.

24. To determine the cluster of logical thinking operation – observation, coding, inference, application and Problem-solving in terms of their contributions to variation in academic achievement in mathematics among General category students.

3.4 Research Hypotheses

In pursuance of the Specific Objectives – 1 to 5 the following research hypotheses were set up :

1. SC and ST, SC and General category, and ST and General category children differ significantly in their logical thinking operation in mathematics– Observation.

2. SC and ST, SC and General category, and ST and General category children differ significantly in their logical thinking operation in mathematics– Coding.

3. SC and ST, SC and General category, and ST and General category children differ significantly in their logical thinking operation in mathematics– Inference.

4. SC and ST, SC and General category, and ST and General category children differ significantly in their logical thinking operation in mathematics– Application.

5. SC and ST, SC and General category, and ST and General category children differ significantly in their logical thinking operation in mathematics– Problem-solving.

In pursuance of the Specific Objectives – 6 to 12, the lowing research hypotheses were set up :

6. Effects of boys and girls differ significantly on attainment of five logical thinking operations, viz., observation, coding, inference, application, and problem-solving.

7 Effects of scheduled and non-scheduled castes differ significantly on five logical thinking operations, viz., observation, coding, inference, application, and problem solving.

8. Effects of favorable and un-favourable attitude differ significantly on five logical thinking operations, viz., observation, coding, inference, application, and problem-solving.

9. Interaction effects of sex and caste differ significantly on five logical thinking operations, viz., observation, coding, inference, application, and problem-solving.

10. Interaction effects of sex and attitude differ significantly on five logical thinking operations, viz., observation, coding, inference, application, and problem-solving.

11. Interaction effects of caste and attitude differ significantly on five logical thinking operations, viz., observation, coding, inference, application, and problem-solving.

12. Interaction effects of sex, caste and attitude differ significantly on five logical thinking operations, viz., observation, coding, inference, application, and problem-solving.

In pursuance of the Specific Objectives – 13 to 15, the following research hypotheses were set up :

13. There exists a significant relationship between logical thinking operations, viz., observation (H_1), coding (H_2), inference (H_3), application (H_4), and Problem-solving (H_5), and academic achievement in mathematics among SC category students.

14. There exists a significant relationship between logical thinking operations, viz., observation (H_6), coding (H_7), inference (H_8), application (H_9), and Problem-solving (H_{10}) and academic achievement in mathematics among ST category students.

15. There exists a significant relationship between logical thinking operations, viz., observation (H_{11}), coding (H_{12}), inference (H_{13}), application (H_{14}), and Problem-solving (H_{15}) and academic achievement in mathematics among General category students.

In pursuance of the Specific Objectives 16 to 18, the following research hypotheses were set up :

16. There exists a joint direct and indirect effects of observation (H_{16}), coding (H_{17}), inference (H_{18}), application (H_{19}) and Problem-solving (H_{20}) on academic achievement in mathematics among SC category students.

17. There exists a joint direct and indirect effects of observation (H_{21}), coding (H_{22}), inference (H_{23}), application (H_{24}) and Problem-solving (H_{25}) on academic achievement in mathematics among ST category students.

18 There exists a joint direct and indirect effects of observation (H_{26}), coding (H_{27}), inference (H_{28}), application (H_{29}) and Problem-solving(H_{30}) on academic achievement in mathematics among General category students.

3.5 Scope of the Study

The study is confined to Dharwad district in Karnataka state. Dharwad district is situated in the western section of the Northern half of the Karnataka state. It has five talukas, viz , Dharwad, Hubli, Kal ghatgi, Navalgund and Kundgol. According to 1991 census, Kalghatgi taluka with total literacy rate 44.00 per cent (male 56.64, female 30.54) is considered as lowest literacy taluka in the entire district. In the present study, Kalghatgi taluka has been considered as disadvantaged taluak with the following statistics.

Name of Block	Area Sq. (Kms)	Population Total as per 1991 census	Population Male	Population Female	Population Range
Kalghatgi	682.8	121248	62700	58548	121248

Population Urban	Population SC	Population ST	Number of Workers	Density (Sq) Kms	Sex Ratio
0	13437	1099	44400	177	930

Further, the present study was restricted to secondary level with a focus on IX standard students, in Kalghatgi taluka. As the logical thinking operations pertains to reasoning in mathematics the present study for the purpose of analysis is limited only to the academic achievement of students in mathematics.

For the purpose of the study, only five logical thinking operations, viz., Observation, Coding, Inference, Application and Problem solving were selected.

3.6 Definitions of Technical Terms

Thinking Operations

Thinking Operations are activities which encourage thinking and which involve many kinds of thinking.

The selected thinking operations for the present study are Observation, Coding, Inference, Application and Problem-solving.

Observation

It is the skill or an ability to get the information about one's environment either directly through one's sense or through the written word or symbol and is expressed in the form of statement and facts.

Coding

Coding is the operation of thinking which helps to assign symbols for objects and ideas.

Inference

In order to process the information that is sensed, touched and felt a student has to go beyond the process of observation i.e., he has to infer the observed facts, identify the correct reason and arrive at a conclusion.

Application

Application is the ability of applying abstractions such as ideas, principles, rules, theories, concepts, etc to mathematical problem and concrete new situations.

Problem-solving

Problem-solving is the integrated activity of perception, memory, recall association, generalization and reconstruction of ideas. It is the formal reasoning of a complete nature.

Total Achievement

Total marks of the five logical thinking operations in mathematics were treated as total achievement scores in mathematics.

Achievement Test

A test that measures the extent to which a person has achieved – something acquired certain information or mastered certain skills – usually as a result of specific instruction. In the present study the test constructed on IX standard mathematics in regional language considered as an achievement test

Attitude

An attitude may be defined as a tendency to react favourably or unfavourably towards a designated class of stimuli such as an institution or persons or objects. It is the sum total of child's feelings and inclinations, prejudices or bias

Thurstone (1931) . Attitude is the affect for or against a psychological object. The term psychological object may refer to a physical object, a person, an idea, a plan of action, a form of conduct . In fact, it may refer to any idea about which the subject may express positive or negative affect

Chave (1928) : An attitude is a complex of feelings, desires, fears, convictions, prejudices or other tendencies that have given a set of readiness to act to a person because of varied experiences.

Krech and *Crutchfield* (1948) : Attitude is an enduring organisation of motivational, emotional, perceptual and cognitive processes with respect to some aspect of the individual's world.

Thurstone (1931) : The concept 'opinion' will here mean a verbal expression of attitude. Opinion is an index of person's attitude.

Disadvantaged Group

This group involves the Students belonging to SC and ST categories.

Scheduled Caste

As per the Article 341 of the constitution this category includes the castes such as Adi-Karnataka, Adi – Dravida, Banjara (Lambani), Jadamali, Mochi, Bhovi, Korama, Mogera, Mundala, Parvan, etc. in Karnataka.

Scheduled Tribe

As per the Article 342 of the constitution this category includes the castes such as Gowdalu, Hasalaru, Maleru, Kudiya, Malekudi, Valmiki, Nayak, etc. in Karnataka.

Advantaged Group

General Category

The remaining castes such as Brahmins, Jains, Jangams, Veerashiva, Raddi, Vaishya, etc., are included in this category in Karnataka.

CHAPTER – IV

DESIGN OF THE STUDY

Pursuance of the objectives of the study called for –

i. Selection of an appropriate method of research;

ii. Development of logical thinking operation test for the assessment of various logical thinking operations,

iii. Development of academic achievement test in mathematics;

iv Selection of a sample of students studying in IX Standard,

v. Collection of data; and

vi. Selection of appropriate statistical techniques for the analysis of data.

The procedures followed in respect of the above six steps are described in this chapter.

4.1 Research Method

Survey and analytical (descriptive) methods of research were found to be appropriate for the present study.

In the present study, the population consisted of all IX Standard students of Kalghatagi taluka studying during 2001-2002. Caste-wise and gender-wise details of the population are as follows.

Table - 4.1 : Description of the Population (N= 1100)

Category	Gender	No of Students	Total
Scheduled Caste	Boys Girls	80 45	125
Scheduled Tribe	Boys Girls	60 50	110
General Category	Boys Girls	640 225	865
Total		1100	1100

4.2 Variables of the Study

The variables selected on the basis of detailed review of related literature are as follows :

Independent Variables . Logical thinking operations like observation, coding,inference, application and problem solving.

Dependent Variable : Academic achievement in mathematics

4.2 Data Collection Tools

4.2.1 Development of Logical Thinking Operations Test in Mathematics

The review of related literature, research studies, recommendations of the Commissions and Committees on mathematics education helped the investigator to arrive at the list of logical thinking operations in mathematics. The logical thinking operations include observation, coding, inference, application and problem-solving. The investigator was specifically given to understand that: (i) the available achievement test in mathematics is inappropriate to measure the logical thinking operations; and (ii) there was no test available to measure the thinking operations in mathematics. Therefore, the efforts were made in the present study to develop a

logical thinking operations test in mathematics using scientific procedure.

(a) Constructing and / or Pooling of Test Items

The test items on five logical thinking operations were constructed on the basis of mathematics text-book of IX Standard prescribed by the Government of Karnataka. Test item was selected/constructed keeping in mind the thinking operation in mathematics. Test item was of multiple choice type with four alternative choices. One of these was the correct answer while the others were distracters.

Multiple choice test was selected on the assumption that, it can measure a variety of learning outcomes like understanding, application, discrimination, interpretation and differentiation of the relationship etc. Hence, this type of question will avoid the effect of mere memory and factual knowledge and thus give more stress on thinking.

The following sources were consulted for construction and /or pooling of test items in mathematics :

i. A textbook of IX Standard mathematics published by the Government of Karnataka, Bangalore,

ii. Review of research and / or theoretical underpinnings,

iii. Other similar tools,

iv. Requesting teachers of mathematics teaching at IX Standard to write statements, such a process ensures content validity,

v. A Text Book of Mathematics for IX Standard- published by National Council of Educational Research and Training, New Delhi, 1999, and

vi. Personal experiences of the investigator and subject teachers.

(b) Preparation of Blue Print

The blue print in Table 4.2 gives the details of the final form of the test in terms of thinking operations, the content and the number of questions framed

Table – 4.2 : Blue Print for the Construction of a Test on Logical Thinking Operations in Mathematics

Sl. No.	Thinking Operations	Topics	Specifications	No. of Qus.	Marks
1.	Observation	Polynomial Mensuration of solids Graphs of linear equations	Identification of the Class Identification of characteristic features Location of features	3 3 4	10
2.	Coding	Congruence Graphs of Linear equations Cylinder	Location of features with symbols Interpretation of symbols Translation in to Symbols	3 3 4	10
3	Inference	Sets & Relations Real Number System Aromatic Approach to Geometry Square	Infer the observed facts Identify the correct reason Arrive at a conclusion	3 3 4	10
4.	Application	Identities Cube Sets & Relations Polynomials	Using equations Giving reasons Predicts happening	3 3 4	10
5.	Problem–Solving	Solutions of Equations in two variables Trig nometric Ratios similarity & similar Triangles	Analyse the problem Determining the operations which may be applied Arrive at a conclusion	4 2 4	10

(c) Screening of Test Items

A screening committee consisting of representatives of mathematics teachers in Secondary Schools, method masters of

mathematics in Colleges of Education, and lectures in mathematics at Degree colleges was formed.

A test on logical thinking operations in mathematics with blue print was submitted to a group of experts. They were requested to go through the draft keeping in view the following aspects :

i. The given items will measure the objective and the skill required

ii. The language and the use of vocabulary

iii. The relevance and suitability of each item under each skill

iv. The specificity and clarity of each test item

v Suitability of the distracters used

This was done with a view to retain one of the synonymous items, and the items which could fit into the framework of the logical thinking operations. Items which were vague were discarded and remaining items were edited to make it clear.

(d) Writing of Directions

Suitable and clear instructions to the students were given on the top of the each item in each thinking operations. Further, the mode of giving response to the various items of the operation was also illustrated with specific example. The test was then translated into

kannada and was submitted to four experienced teachers to check the errors due to translation

(e) Preparation of the Initial Draft

The list of sixty two test items was used to prepare a entire logical thinking operations based test in mathematics for IX Standard. The test was tried out in 10 high schools in Kalghatagi taluka. In order to administer the test, the co-operation of the school teachers was sought. The students were specifically given to understand that, (i) there was 1 hour time limit for completing the test; (ii) the scores of the test would be used only for research purpose; and (iii) the honest and accurate answers of the students to test items would help the study in developing a reliable test in mathematics. The test was administered to 100 students studying in IX Standard

(f) Scoring

The answers to the test items were of the type right or wrong. Therefore, one mark was awarded to each right answer given by the student Maximum score that could be obtained on each logical thinking operation, therefore, would be on an average six to eight marks. Sum of the item sores under each operation gave the score on each logical thinking operation. The score for each operation was calculated separately.

(g) Item Analysis

Each test item was subjected to analysis in terms of (i) difficulty value, and (ii) item validity. For this purpose, the scores obtained by the Ss (n= 100) were first arranged in the descending order. The two groups - 'high scoring' and 'low scoring', each composed of 27 per cent of the 100 sample, formed the basis for the computation of difficulty and validity indices.

i. Difficulty Index

The difficulty value of each test item was determined by using the following formula :

$$D = \frac{U + L}{2}$$

Where,

D = difficulty value of the item;

U = percentage of students scoring the item correctly in the upper or higher scoring group; and

L = percentage of students scoring the item correctly in the lower or low scoring group.

The difficulty values of the test items are shown in the Table – 4.3.

ii. Item Validity

For determining item validity, numerous indices and procedures are available. In the present study, the correlation approach, correlating the item score with the test score was followed. For computing item test correlation the 'Point–biserial correlation method'

(Guilford, 1954, p. 427) was used. The choice of this method was based on two considerations : (i) One of the variables namely item score is in the form of genuine dichotomy - 1 or 0; (ii) Labour saving 'abac' is developed by Flanagan for determining estimates or r_{pbis}.

The item validity values of the final test are shown in the Table - 4.3

Table – 4.3 : Difficulty Index and Discrimination Index of the Logical Thinking Operations Test in Mathematics for IX Standard

Item No.	Upper group Score	Lower group Score	Difficulty Index	Discrimination Index	Significance at 0.05 level
1	2	3	4	5	6
1	22(81.48)	16(59.25)	70.37	0.28	Yes
2	26(96.30)	22(81.49)	88.90	0.26	Yes
3	06(22.22)	02(07.40)	14.81	0.31	Yes
4	15(55.55)	07(25.92)	40.73	0.30	Yes
5	07(25.92)	01(03.70)	14.81	0.51	Yes
6	18.(66.67)	07(25.92)	46.29	0.41	Yes
7	09(33.33)	04(14.81)	24.07	0.27	Yes
8	21(77.78)	11(40.74)	59.26	0.38	Yes
9	06(22.22)	02(07.40)	14.81	0.31	Yes
10	17(62.97)	09(33.33)	48.15	0.29	Yes
11	23(85.18)	16(59.25)	72.21	0.34	Yes
12	17(62.97)	05(18.51)	40.71	0.47	Yes
13	17(62.97)	10(37.03)	49.10	0.25	Yes
14	19(70.37)	13(48.14)	59.30	0.25	Yes
15	25(92.59)	18(66.67)	79.63	0.34	Yes
16	15(55.53)	08(29.62)	42.58	0.25	Yes
17	07(25.92)	02(07.40)	16.67	0.36	Yes
18	17(62.92)	09(33.33)	48.12	0.29	Yes
19	12(44.44)	01(03.70)	24.07	0.63	Yes
20	08(29.62)	02(07.40)	18.51	0.40	Yes
21	08(29.62)	01(03.70)	16.67	0.55	Yes
22	14(51.84)	03(11.11)	31.48	0.48	Yes
23	23(85.18)	16(59.25)	72.21	0.34	Yes
24	20(74.07)	14(51.84)	62.97	0.26	Yes
25	14(51.84)	02(07.40)	29.62	0.56	Yes

Contd ..

1	2	3	4	5	6
26	08(29.62)	01(03.70)	16.67	0.55	Yes
27	22(81.48)	17(62.92)	72.20	0.25	Yes
28	15(55.58)	08(29.62)	42.58	0.25	Yes
29	16(59.25)	07(25 92)	42 59	0.33	Yes
30	10(37.03)	04(14 81)	25 92	0.31	Yes
31	18(66.67)	07(25.92)	46.30	0.41	Yes
32	25(92.60)	18(66.67)	79.64	0.34	Yes
33	20(74.07)	08(29.62)	51.85	0.44	Yes
34	17(62.92)	06(22.22)	42 57	0.42	Yes
35	24(88 89)	08(29.62)	59 26	0.57	Yes
36	22(81 48)	10(37.03)	59 26	0.47	Yes
37	22(81.48)	02(07.40)	44.44	0 76	Yes
38	21(77.78)	08(29.62)	53.70	0.49	Yes
39	26(96.30)	12(44.44)	72.22	0 59	Yes
40	16(59.62)	02(07.40)	33.51	0.61	Yes
41	17(62.92)	03(11.11)	37.02	0.57	Yes
42	18(66.67)	05(18.51)	42.59	0.49	Yes
43	21(77.78)	08(29.62)	53.70	0.49	Yes
44	14(51.84)	03(11.11)	31.48	0.48	Yes
45	13(48.14)	03(11.11)	29.63	0.48	Yes
46	15(55.55)	07(25.92)	40.74	0 30	Yes
47	11(40.74)	01(03.70)	22.22	0.61	Yes
48	19(70.37)	05(18.51)	44.44	0.53	Yes
49	18(66.67)	08(29.62)	48.15	0.37	Yes
50	16(59.62)	04(14.81)	37.22	0.48	Yes

(h) Final Tool

Items with 100 per cent and 0 per cent difficulty value and items with less than 0.25 validity coefficients were deleted (Thorndike,

1966, p. 245). Such items must be carefully examined for ambiguities, inaccuracies and other errors. As a result of the final analysis - determination of 'D' values, no item was omitted. However, as a result of the second analysis - determination of 'r' values, Item Nos. 4, 5, 7, 8, 11, 14, 17, 22, 31, 35, 49, 53 were omitted. The final tool consisted of 50 multiple choice items with a total score of 50. The directions for using the test were found to work well and were retained without modification. See Appendix – I for the final tool along with the directions.

(i) Reliability of the Test

i. Coefficient of Stability

The coefficient of stability of the test was determined by the test-retest method. For this purpose the test was administered to a random sample of 50 students out of 100 involved in the first tryout two weeks after the first administration. Then correlation between the test and retest scores was computed. The coefficient of correlation between the two sets of scores on the test was found to be 0.972 which is quite significant at 0.05 level. This implies that the test has stability reliability.

ii. Coefficient of Consistency

The coefficient of consistency of the test was determined by the split-half method. For this purpose, scores obtained on re-administration of the test to the 50 Ss involved for determining stability reliability value were used. The total scores were divided into

two halves -- one relating to odd numbered items and the other to even numbered items. The obtained coefficient of correlation between the scores on the halves was corrected for full length of the test by means of Spearman-Brown prophecy formula. The coefficient of consistency of the test was found to be 0.60 which is significant at 0.05 level. This implies that the test has consistency reliability

(j) Validity

i. Construct Validity

Construct validity of the test was determined by establishing the correlation between each logical thinking operation with that of total achievement in mathematics. An operation that correlates significantly with total achievement in mathematics would be said to have construct validity. The obtained validity coefficients are as follows :

Observation	---	0.664
Coding	---	0 804
Inference	---	0.735
Application	---	0.521
Problem-solving	---	0.583

This implies that all the logical thinking operations are having positive and significant correlation with the total achievement in mathematics. Thus, construct validity of the test is established.

ii. Intrinsic Validity

Intrinsic Validity of the test was computed from its reliability coefficients (Guilford, 1954, p. 399). The range of validity coefficients was between 0.755 to 0.980 which speaks of the intrinsic validity of the test.

iii. Content Validity

Five mathematics teachers of IX Standard acted as judges in establishing content validity of the test. They examined the test items, the comprehensiveness of the test, administration procedure and the scoring key for relevance and plausibility. The judges were fully satisfied with the relevance of the test items, comprehensiveness, administration procedure and the scoring procedure. This implies that the 'Logical Thinking Operation Test in Mathematics' was found to be comprehensive and relevant.

(k) Administration of the Test

The final form of the test on 'Logical Thinking Operations in Mathematics' was administered to 30 students in each school and 303 students of IX Standard studying in Aided, Government, and Un-Aided schools located in the area of Kalghatagi taluk of Dharwad district. Duration of the test was sixty minutes only.

4.3.2 Construction of an Attitude Scale towards Mathematics

To measure the attitude of IX Standard students towards mathematics, the investigator constructed an attitude scale.

Attitude is one's disposition towards particular object, event or person. It can be favourable, unfavourable or natural. Attitudes can be measured by (i) observing behaviour, (ii) asking subjects to respond to partially structured situations, (iii) setting them to perform certain tasks, or (iv) using self-report techniques.

In the last technique, which uses opinions as an index of the individual's attitude, subjects respond to a set of carefully selected statements from a universe of content. This technique was adopted to construct an attitude scale.

There are a number of self reporting techniques. The most popular among them are Thurstone's equal appearing intervals, Guttman's scalogram analysis and Likert's method of summated rating. The last method was used in the construction of an attitude scale. In a Likert type attitude scale, preliminary trial is given to a series of statements, half of which are favourable and the others are unfavourable. The responses of these statements could be 'strongly agree', 'agree', 'undecided', 'disagree' or 'strongly disagree'.

The following are the steps involved in the development of the Likert scale :

i. Obtaining statements

ii. Editing the statements

iii. Try-out

a. Construction of the scale

b. Scoring

c. Item analysis

iv Establishing reliability and validity

v. Interpretation of the scores

i. Obtaining Attitudinal Statements

The following were the sources consulted :

a. Review of research and / or theoretical underpinnings.

b. Other similar tools like :

i An Attitude Scale for Mathematics by H. G. Desai

ii. Mathematics Attitude Scale by Mulkh Raj Tuli

c. Requesting representative members of the target group to write statements. Such a process ensures content validity.

d. Personal experience.

It was decided to consider the following aspects for construction of an attitude scale towards mathematics. They were :

1. Attitude towards mathematics teacher
2. Attitude towards methods of teaching mathematics
3. Attitude towards mathematics text book
4. Attitude towards mathematics syllabus
5. Attitude towards evaluation in mathematics
6. Attitude towards mathematics as a subject

ii. Editing the Statements

1. Statements are clearly edited keeping in view certain criteria.

2. The items are designated as either positive or negative. If an item cannot be perceived clearly as being either positive or negative, such a statement was discarded.

3 The wording of the statement should suit grammatically the words chosen to indicate the degree of favourableness on the continuum.

4. The statements were classified into different sub-scales or areas

iii. Try-out

(a) Construction of the Scale

Corresponding to each of the attitudinal object, suitable specifications were written and a number of statements were prepared under each category, including both favourable and unfavourable attitudes. The initial collection of eighty-five items contained fourty three positive and fourty two negative statements.

The initial draft of the scale was then submitted to a group of experts in the field of Teacher Education. They were asked to evaluate the statements keeping in mind the following aspects :

i. Accuracy and relevance of each statement

ii. Level of language according to the standard of students

iii. Objectivity and specificity

According to their suggestions, some of the items were deleted in order to have equal number of positive and negative statements. The final form of the scale consisted of seventy four statements, thirty seven negative and thirty seven positive.

Table – 4.4 : Blue Print Showing the Nature of the Statements and Number of Statements in the Attitude Scale

Category		Nature of the Statement	No. of Statements
1		2	3
I. Mathematics Teacher	1	Understanding mathematics is very easy which is full of digits and numbers. (+)	
	2.	Mathematics creates interest. (+)	
	3.	Mathematics is boring as it involves imaginary aspects. (-)	
	4.	Teaching mathematics in class room initiates bunking it. (-)	
	5.	Giving mathematics more time and working on it helps to gain mastery over it. (+)	
	6.	Mathematics includes old concepts, therefore, it is a headache. (-)	
	7.	Mathematics does not move with time and includes only old topics. (-)	
	8.	Solving Geometrical problems helps the mind to be enthusiastic.	
	9.	More often mathematics involves only Problem-solving so it bores. (-)	
	10.	Since mathematics contain algebra, geometry, therefore various numbers can be learnt. (+)	
	11.	Teaching mathematics helps the mind to be active. (+)	
	12.	As mathematics contains more numbers, therefore it creates confusion during teaching in class. (-)	
	13.	Teaching mathematics in class room arises fears. (-)	
			13

Cont.. . .

1	2	3
II. Methods of Teaching Mathematics	14. Teaching maths with help of graphs is very interesting. (+)	
	15. Mathematics also includes Angles, Triangles, Graphs etc., which makes it interesting to teach. (+)	
	16. Problems of Algebra and their teaching have failed to arise interest in students. (-)	
	17. Teaching Geometry with Geometrical apparatus creates a good impact. (+)	
	18. Teaching maths in classroom or in a confined room is less influential. (+)	
	19. Teaching theorems in geometry has increased interest in students. (+)	
	20. Teaching mathematics sequentially results in effectiveness. (+)	
	21 The problems in algebra are more complex. Therefore teaching of mathematics is not successful. (-)	
	22. Teaching mathematics through various models helps for effective teaching. (+)	
	23. Mathematics fails to draw the interest of the student, as it is more practical oriented. (-)	
		10
III Mathematics text book	24. Text book of mathematics being attractive arises interest in students to study. (+)	
	25. Maths textbooks cover has on its top, figures of scale, triangle, rubber, divider etc., make it attractive. (+)	
	26. Covers of maths textbook are very thin and are of poor quality. (-)	
	27. The last cover of maths textbook does not have any figure on it, so the textbook loses its beauty. (-)	
	28. The maths textbook is not finely printed.(-)	
	29. The maths textbook is attractive because it contains algebra and geometry. (+)	
	30. The national anthem should be printed in first page of mathematics textbook, but it is not so, therefore it is not good. (-)	

Cont. ..

1	2	3
		3
	31. Printing of the rules and regulations meant for a citizen on the last page of maths textbooks helps the students to understand their responsibilities. (+)	
	32. The picture printed on the front page of maths textbook helps students to improve creativity towards maths. (+)	
	33. The pages used for printing of maths textbook are of low quality. (+)	
	34. The photographs of mathematics scientists could have been printed on last page but it is not so, therefore it is not good. (-)	
	35. The textbook of maths helps the students to solve their problems and test their mental ability. (+)	
	36. The maths textbook has a high price which is burden on the students. (-)	
	37. Textbook includes more matter about blindness, therefore it has failed to draw concentration of students. (-)	
	38. Along with numbers, maths textbook also contains figures, therefore, it is more attractive. (+)	
	39 The index in maths textbook is in sequential order and in good form. (+)	
	40. As maths textbook gives details about theorems of geometry, it draws student's attention. (+)	
		17
IV. Mathematics Syllabus	41. The subject index do not contain figures, therefore it has failed to draw attention of students. (-)	
	42. As maths contain algebra, arithmetic, it is helpful for students to understand more about numbers. (+)	
	43. Understanding maths with the help of graphs makes it more attractive. (+)	
	44. The maths subject does not have attractive coloure pictures. (-)	
	45. The subject of maths does not have many examples so it is not valid. (-)	
	46. The maths subject does not have topics on Indian mathematicians, so it fails to impress students. (-)	

Cont.......

1	2		3
	47.	The subject of maths has no units which could enhance the students mental abilities. (-)	
	48.	The subject of maths has numbers and digits, which helps students in understanding it. (+)	
	49.	The subject of maths has no issues which relate with the modern world. (-)	
	50.	With the help of mathematics one can have easy transactions in day today life. (+)	
	51	Mathematics has helped students to gain absolute answers. (+)	
	52	As maths contains more about numbers, therefore it has failed to evoke interest among students. (-)	
V. Evaluation in Mathematics			12
	53.	By giving assignments to students of previous chapters it helps them to understand next chapter more clearly. (+)	
	54	Using black boards for evaluation of mathematics is very useful.	
	55.	Directing students to solve problems of algebra, arithmetic, geometry helps in effective evaluation. (+)	
	56.	All students solve problems in different manner, methods and arrive at different conclusions so evaluation fails. (-)	
	57.	Mathematical evaluation includes only practical knowledge so it fails to arose interest in students. (-)	
	58.	Evaluation in maths helps in developing knowledge about numbers among students. (+)	
	59.	Asking more questions regarding numbers during evaluation has failed to draw student's attention. (-)	
	60.	Evaluation in maths helps students to understand problems in day-today life. (+)	
	61.	Evaluation in mathematics has helped students in developing knowledge related to business. (+)	

Cont . . .

1	2	3
	62. As mathematics deals only with numbers, it fails to create desirable attitude towards the subject (-)	
	63 In the subject of mathematics as same pattern of questions exist, it fails to draw the attention of the students. (-)	
	64. Evaluation in maths contains no questions which concrete interests among students. (-)	
		12
VI Mathematics as a Subject	65. Study of maths helps the students in solving mathematical problems in day-to-day life. (+)	
	66 Study of maths helps the students to improve their mental ability and discipline. (+)	
	67. Study of mathematics has failed to develop aesthetic ability among students. (-)	
	68. Study of maths has failed to make the student for proper use of their leisure (-).	
	69. Study of maths helps student to solve problems independently. (+)	
	70. Study of maths helps students to understand the concepts of maths as well as its correlation with other subjects. (+)	
	71. Study of maths helps the student to improve their moral status and helps them to lead ideal life. (+)	
	72. Study of maths help students to understand the relation of maths in developing culture and civilization. (+)	
	73. Study of maths has failed to teach student to lead simple and good life. (-)	
	74. Study of maths has failed to teach student to study other subject in higher education in maths. (-)	
		10

b. Scoring

The subject is required to respond to each statement on the 5-point scale – 'Always', 'Often', 'Sometimes', 'Rarely' and 'Never' – in such a way as to describe the way in which he generally thinks about the mathematics subject The responses of the subject were assigned numerical values as in Likert type ranging from 1 to 5 depending upon the degree of favourable or unfavourable attitude expressed. Positive statements were scored 5, 4, 3, 2, or 1 and negative statements 1, 2, 3, 4, or 5 depending upon the response of the subject to the statements. Sum-total of all the scores represents the individual's attitude towards mathematics. The total weighted score, if high, indicates a favourable attitude and if low, an unfavourable attitude towards mathematics.

c. Item Analysis

The draft attitude scale in administered to a representative group. The filled in forms are scored and arranged in a descending order.

The top 27% and the bottom 27% of the forms are considered for item analysis the items, which discriminate between individuals with favourable attitudes from individuals with unfavourable attitude have to be selected. For this purpose the t–test is used, the procedure recommended by Edwards (1969) was used. Items with t–values equal to or greater than 1.75 were selected.

The nature of statements, t – values and their significance are given the following table :

Table – 4.5 : Nature of Statement, 't' Values and Significance

Sl. No	Nature of the Statement	't' Value	Significance
1	2	3	4
1	Understanding mathematics is very easy which is full of digits and numbers.	1.75	Yes
2	Mathematics creates interest.	3.97	Yes
3	Mathematics is boring as it involves imaginary aspects.	5.43	Yes
4	Teaching mathematics in class room initiates bunking it.	1.79	Yes
5	Giving mathematics more time and working on it helps to gain mastery over it.	5.34	Yes
6	Mathematics includes old concepts, therefore, it is a headache.	2.84	Yes
7	Mathematics does not move with time and includes only old topics.	3.91	Yes
8	Solving Geometrical problems helps the mind to be enthusiastic.	3.44	Yes
9	More often mathematics involves only Problem-solving so it bores.	3.23	Yes
10	Since mathematics contain algebra, geometry, therefore various numbers can be learnt.	1.86	Yes
11	Teaching mathematics helps the mind to be active.	2.67	Yes
12	As mathematics contains more numbers, therefore it creates confusion during teaching in class.	3.00	Yes
13	Teaching mathematics in class room arises fears.	3.23	Yes
14	Teaching maths with help of graphs is very interesting.	3.97	Yes
15	Mathematics also includes Angles, Triangles, Graphs etc., which makes it interesting to teach.	2.84	Yes
16	Problems of Algebra and their teaching have failed to arise interest in students.	1.75	Yes

Cont. . ..

1	2	3	4
17	Teaching Geometry with Geometrical apparatus creates a good impact.	1.75	Yes
18	Teaching maths in classroom or in a confined room is less influential.	3.09	Yes
19	Teaching theorems in geometry has increased interest in students.	1.75	Yes
20	Teaching mathematics sequentially results in effectiveness	1.75	Yes
21	The problems in algebra are more complex. Therefore teaching of mathematics is not successful.	2.82	Yes
22	Teaching mathematics through various models helps for effective teaching.	2.20	Yes
23	Mathematics fails to draw the interest of the student as it is more practical oriented.	2.21	Yes
24	Textbook of mathematics being attractive aroses interest in students to study	3.05	Yes
25	Maths textbooks cover has on its top, figures of scale, triangle, rubber, divider etc., makes it attractive.	1.75	Yes
26	Covers of maths textbook are very thin and are of poor quality.	1 75	Yes
27	The last cover of maths textbook does not has any figure on it, so the text book loses its beauty.	1 75	Yes
28	The maths textbook is not finely printed.	2.66	Yes
29	The maths textbook is attractive because it contains algebra and geometry.	3.37	Yes
30	The national anthem should be printed in first page of mathematics textbook, but it is not so, therefore it is not good.	3.71	Yes
31	Printing of the rules and regulations meant for a citizen on the last page of maths textbooks helps the students to understand their responsibilities.	2.19	Yes
32	The picture printed on the front page of maths textbook helps students to improve creativity towards maths.	1.75	Yes

Cont .....

1	2	3	4
33	The pages used for printing of maths textbook are of low quality.	2.59	Yes
34	The photographs of mathematics scientists could have been printed on last page but it is not so, therefore it is not good	2.11	Yes
35	The textbook of maths helps the students to solve their problems and test their mental ability.	3 43	Yes
36	The maths textbook has a high price which is burden on the students.	1.75	Yes
37	Textbook includes more matter about blindness, therefore it has failed to draw concentration of students	4.12	Yes
38	Along with numbers, maths textbook also contains figures, therefore, it is more attractive.	5.25	Yes
39	The index in maths textbook is in sequential order and in good form.	2.45	Yes
40	As maths textbook gives details about theorems of geometry, it draws student's attention.	1.75	Yes
41	The subject index do not contain figures, therefore it has failed to draw attention of students.	2.14	Yes
42	As maths contain algebra, arithmetic, it is helpful for students to understand more about numbers.	4.24	Yes
43	Understanding maths with the help of graphs makes it more attractive	2.39	Yes
44	The maths subject does not have attractive coloure pictures.	1 75	Yes
45	The subject of maths does not have many examples so it is not valid.	2.33	Yes
46	The maths subject does not have topics on Indian mathematicians, so it fails to impress students.	3.94	Yes
47	The subject of maths has no units which could enhance the students mental abilities.	1 75	Yes
48	The subject of maths has numbers and digits, which helps students in understanding it.	2.78	Yes
49	The subject of maths has no issues which relate with the modern world.	3.33	Yes

Cont... .

1	2	3	4
50	With the help of mathematics one can have easy transactions in day today life.	2.96	Yes
51	Mathematics has helped students to gain absolute answers.	1.75	Yes
52	As maths contains more about numbers, therefore it has failed to evoke interest among students.	4.49	Yes
53	By giving assignments to students of previous chapters it helps them to understand next chapter more clearly.	3.10	Yes
54	Using blackboards for evaluation of mathematics is very useful.	2.67	Yes
55	Directing students to solve problems of algebra, arithmetic, geometry helps in effective evaluation.	1 75	Yes
56	All students solve problems in different manner, methods and arrive at different conclusions so evaluation fails.	3.00	Yes
57	Mathematical evaluation includes only practical knowledge so it fails to arise interest in students.	4.52	Yes
58	Evaluation in maths helps in developing knowledge about numbers among students.	4.18	Yes
59	Asking more questions regarding numbers during evaluation has failed to draw student's attention.	3.63	Yes
60	Evaluation in Maths helps students to understand problems in day-to-day life.	1.89	Yes
61	Evaluation in mathematics has helped students in developing knowledge related to business.	1.75	Yes
62	As mathematics deals only with numbers, it fails to create desirable attitude towards the subject.	5.29	Yes
63	In the subject of mathematics as same pattern of questions exist, it fails to the draw attention of the students.	3.23	Yes
64	Evaluation in maths evaluation contains no questions which concrete interests among students.	1.87	Yes

Cont.......

1	2	3	4
65	Study of maths helps the students in solving mathematical problems in day-to-day life.	3.09	Yes
66	Study of maths helps the students to improve their mental ability and discipline.	3.43	Yes
67	Study of mathematics has failed to develop aesthetic ability among students.	3.09	Yes
68	Study of maths has failed to make the student for proper use of their leisure.	4.11	Yes
69	Study of maths helps student to solve problems independently.	2.18	Yes
70	Study of maths helps students to understand the concepts of maths as well as its correlation with other subjects.	1.75	Yes
71	Study of maths helps the student to improve their moral status and helps them to lead ideal life.	2.70	Yes
72	Study of maths help students to understand the relation of maths in developing culture and civilization.	1.75	Yes
73	Study of maths has failed to teach student to lead simple and good life.	2.33	Yes
74	Study of maths has failed to teach student to study other subject in higher education in maths.	1.82	Yes

Note : Statements with 't' values equal to or greater than 1.75 were selected.

iv. Establishing Reliability and Validity

a. Coefficient of Stability

The coefficient of stability of the scale was determined by the test-retest method. For this purpose, the scale was administered to a random sample of 50 students out of 100 involved in the first tryout two weeks after the first administration. Then correlation between the test and retest scores was computed. The coefficient of correlation

between the two sets of scores on the scale was found to be 0.66 which is quite significant at 0.05 level. This implies that the scale has stability reliability.

b. Coefficient of Consistency

The coefficient of consistency of the scale was determined by the split-half method. For this purpose, scores obtained on re-administration of the scale to 100 Ss involved in determining stability reliability were used. The total scores were divided into two halves– one relating to odd numbered items and the other to even numbered items. The obtained coefficient of correlation between the scores on the halves was corrected for full length of scale by means of Spearman-Brown prophecy formula. The coefficient of consistency of the scale was found to be 0.89 which is significant at 0.05 level. This implies that the scale has consistency reliability.

c. Intrinsic Validity

Intrinsic validity of the scale was computed from its reliability coefficients (Guilford, 1954, p. 399). The range of validity coefficients was between 0.812 and 0.943 which speaks of the intrinsic validity of the scale

d. Content Validity

Five teachers of mathematics acted as judges in establishing content validity of the scale. They examined the statements, the instructions and the scoring procedure. They were fully satisfied with

the relevance and plausibility of the statements and the scoring procedure. They were also satisfied with the adequate coverage of the attitudinal areas in mathematics. This implies that the attitude scale towards mathematics was found to be comprehensive and relevant. See Appendix – II for the scale along with the directions.

4.3.3 Development of Academic Achievement Test in Mathematics

Since the available tests for the assessment of academic achievement in mathematics of IX Standard were not found to be satisfactory in terms of their comprehensiveness and relevance. The academic achievement test in mathematics test was developed using the standard scientific procedure

The procedure used for the construction and validation of achievement test is described :

In all 50 items were listed under three areas of mathematics such as algebra, arithmetic and geometry.

a. Constructing and / or Pooling of Test Items

The test is to be administered to students who are studying in secondary schools of Kalghatagi taluka (Dharwad district) whose mother tongue/regional language is Kannada. Hence, the test items in mathematics are written in regional language only.

The following sources were consulted for construction and / or pooling of test items in mathematics :

i. A textbook of IX Standard mathematics published by the Government of Karnataka, Bangalore.

ii. Review of research and / or theoretical underpinnings,

iii. Other similar tools,

iv. Requesting representative teachers of mathematics to write test items, (such a process ensures content validity),

v. A textbook of Mathematics for IX Standard published by National Council of Educational Research and Training, New Delhi, 1999, and

vi. Personal experience of the investigator and subject teachers.

b. Preparation of Blue – Print

A three dimensional blue-print showing coverage of content, instructional objectives and types of items was prepared by referring to the IX Standard textbook of mathematics. The blue-print is as follows :

Table – 4.6 : Blue-Print for the Academic Achievement Test in Mathematics

Sl. No	OBJECTIVES	KNOWLEDGE			UNDERSTAND-ING			APPLICATION			SKILL			TOTAL
	Specifications	O	S	E	O	S	E	O	S	E	O	S	E	
	ARITHMETIC													
1	Number System	2(2)	-	-	-	-	-	1(1)	-	-	-	-	-	3 (3)
2	Sets and Relations	2(2)	-	-	2(2)	-	-	2(2)	-	-	-	-	-	6 (6)
3	Ordered Pairs	1(1)	-	-	1(1)	-	-	-	-	-	-	-	-	2 (2)
4	Functions	1(1)	-	-	-	-	-	-	-	-	-	-	-	1 (1)
5	Commercial Mathematics	2(2)	-	-	-	-		-		-	-	-	-	2 (2)
	ALGEBRA													
6	Factorization	2(2)	-	-	2(2)	-	-	1(1)	-	-	-	-	-	5 (5)
7	Polynomial	-	-	-	1(1)	-	-	-	-	-	-	-	-	1 (1)
8	Algebraic Expressions	-	-	-	1(1)	-	-	-	-	-	-	-	-	1 (1)
9	Solutions of Equations in two Variables	2(2)	-	-	-	-	-	-	-	-	-	-	-	2 (2)
	GEOMETRY													
10	Revision Exercise	4(4)	-	-	2(2)	-	-	-	-	-	1(1)	-	-	7 (7)
11	Congruence	2(2)	-	-	-	-	-	-	-	-	-	-	-	2 (2)
12	Aromatic Approach to Geometry Square	-	-	-	-	-	-	-	-	-	4(4)	-	-	4 (4)
13	Graphs of Linear Equations Type y = mx, Y= mx + c	1(1)	-	-	2(2)	-	-	-	-	-	-	-	-	3 (3)
14	Trigonometric Ratios Similarity and Similar Triangles	-	-	-	2(2)	-	-	-	-	-	-	-	-	2 (2)
15	Surface Area and Volumes of Solids	6(6)	-	-	1(1)	-	-	2(2)	-	-	-	-	-	9 (9)
	TOTAL	25 (25)			14 (14)			6 (6)			5 (5)			50(50)

* Figures out side the brackets indicate the marks
* Figures within the brackets indicate the number of questions
* O – Objective type, S – Short answer type, E – Essay type.

Table – 4.7 : Preparation of Three-Dimensional Chart

Objective Weightage

Sl. No	Instructional Objectives	Marks	Percentage
1	Knowledge	25	50
2	Understanding	14	28
3	Application	06	12
4	Skill	05	10
	Total	50	100

Content Weightage

Sl. No.	Content / Sub-Unit	Marks	Percentage
1	Arithmetic	14	28
2	Algebra	09	18
3	Geometry	27	54
	Total	50	100

Question Type Weightage

Sl. No.	Type of Question	Marks	Percentage
1	Objective Multiple Choice Questions	50	100
	Total	50	100

c. Screening of Test Items

The preliminary pool consisted of 61 test items. The pool was screened for discarding synonymous test items. As a result of this 11 test items were rejected and a pool of 50 test items remained. Thus the pool of 50 test items was ready for tryout and item analysis.

d. Writing of Directions

Suitable directions were given on the top of the each test item. Further, the mode of giving response to the various items was illustrated with specific example.

e. Tryout

Before constructing the test items, the investigator has done a thorough study of the methodology and objectives of mathematics. The initial test was tried out in two secondary schools in Kalghatagi taluka. In order to administer the test, the co-operation of the school teachers was sought. The students were specifically given to understand that : (i) the test is of one hour duration; (ii) the scores of the test will be used only for research purpose; and (iii) the honest and accurate answers of the students to test items will help the investigator in developing a reliable test in mathematics. 100 students studying the IX Standard in the Government High School, Kalghatagi and S. B. B. High School, Bammigatti were asked to respond to the test items.

f. Scoring

The test items were of the multiple-choice types with four alternative choices. The student has to identify the correct answer. One mark was awarded to each right answer given by the student. Sum of the item scores was the score on academic achievement in mathematics. The score for each student was calculated separately.

g. Item Analysis

Each test item was subjected to analysis in terms of i) difficulty value, and ii) item validity. For this purpose the scores of 100 Ss taken for the tryout were selected The scores of the Ss (n = 100) were first arranged in the descending order The two groups – 'high scoring' and 'low scoring', each composed of 27 per cent, i.e., 27 of the Ss of the sample 100 formed the basis for the computation of validity and difficulty indices.

For determining item validity, numerous indices and procedures are available. In the present study the correlation approach, i.e., correlating the item score with the test score was followed. For computing item test correlation the 'Point-biserial correlation method' (Guilford, 1954, p. 427) was used. The choice of this method was based on two considerations : (i) One of the variables, namely, item score is in the form of genuine dichotomy (1 or 0) ; (ii) Labour saving 'abac' is developed by Guilford for determining estimates of r_{pbis}.

The item validity values of the test items are shown in the Table – 4.8.

The difficulty value of each test item was determined by using the following formula :

$$D = \frac{U + L}{2}$$

Where, D = difficulty value of the item;

U = percentage of students scoring the item correctly in the upper or higher scoring group; and

L = percentage of students scoring the item correctly in the lower or low scoring group.

Table – 4.8 : Discrimination Index and Difficulty Index of Achievement Test in Mathematics for IX Standard

Test Item	Upper Limit (U)	Lower Limit (L)	Discrimination Index	Difficulty Index	Significance at 0.05 level
1	2	3	4	5	6
1	44	12	0.48	28.0	Yes
2	67	37	0.34	52.0	Yes
3	27	00	0.52	13.5	Yes
4	96	78	0.35	87.0	Yes
5	66	44	0.29	55.0	Yes
6	75	07	0.72	41.0	Yes
7	61	30	0.39	45.5	Yes
8	93	59	0.46	76.0	Yes
9	67	37	0.39	52.0	Yes
10	30	07	0.36	18.5	Yes
11	78	44	0.44	61.0	Yes
12	64	22	0.51	43.0	Yes
13	47	07	0.53	27.0	Yes
14	33	04	0.49	18.5	Yes
15	74	26	0.55	50.0	Yes
16	78	59	0.25	68.5	Yes
17	37	19	0.27	28.0	Yes
18	85	48	0.48	66.5	Yes
19	81	52	0.39	66.5	Yes
20	41	07	0.48	24.0	Yes
21	74	33	0.49	53.5	Yes
22	52	07	0.56	29.5	Yes
23	74	33	0.49	53.5	Yes
24	52	07	0.55	29.5	Yes
25	74	52	0.28	63.0	Yes
26	78	30	0.54	54.0	Yes

Contd...

1	2	3	4	5	6
27	63	26	0.45	44.5	Yes
28	100	69	0.55	84.5	Yes
29	22	00	0.49	11.0	Yes
30	52	19	0 42	35.5	Yes
31	22	03	0 39	12.5	Yes
32	81	37	0.52	59.0	Yes
33	96	81	0.32	88.5	Yes
34	30	00	0.52	15.0	Yes
35	26	03	0.42	14.5	Yes
36	26	11	0.29	18 5	Yes
37	19	05	0.30	12 0	Yes
38	59	30	0.37	44.5	Yes
39	41	04	0.57	22.5	Yes
40	86	09	0.75	47.5	Yes
41	27	07	0.38	17.0	Yes
42	59	07	0.64	33.0	Yes
43	81	41	0.49	61.0	Yes
44	37	04	0.53	20.5	Yes
45	89	11	0.76	50.0	Yes
46	100	81	0.40	90 5	Yes
47	46	17	0.39	31.5	Yes
48	93	59	0.49	76.0	Yes
49	74	19	0.60	46.5	Yes
50	33	09	0.36	21.0	Yes

h. Final Tool

Items with 100 per cent and 0 per cent difficulty value and items with less than 0 25 validity coefficients were deleted (Thorndike, 1966, p. 245). As a result of the first analysis–determination of 'D' values, and as a result of the second analysis – determination of 'r

values, out of the total number of 61 test items, 11 items were rejected. The final tool consisted of 50 items in all. The directions for using the test were found to work well and were retained without modification. See Appendix - III for the final tool along with the directions.

i. Reliability of the Achievement Test

i. Coefficient of Stability

The coefficient of stability of the achievement test was determined by the test-retest method. For this purpose, the achievement test was readministered to a random sample of 50 students out of 100 involved in the first tryout two weeks after the first administration. Then correlation between the test and retest scores was computed. The coefficient of correlation between the two sets of scores on the achievement test was found to be 0.92 which is quite significant at 0.05 level. This implies that the achievement test has stability reliability.

ii. Coefficient of Consistency

The coefficient of consistency of the achievement test was determined by the split-half method. For this purpose, scores obtained on re-administration of the achievement test to 100 Ss involved for determining stability reliability value were used. The total scores were divided into two halves - one relating to odd numbered items and the other to even numbered items. The obtained coefficient of correlation between the scores on the halves was corrected for full

length of achievement test by means of Spearman – Brown prophecy formula. The coefficient of consistency of the achievement test was found to be 0.978 which is significant at 0.05 level. This implies that the achievement test has consistency reliability.

j. Validity of the Achievement Test

i. Intrinsic Validity

Intrinsic validity of the achievement test was computed from its reliability coefficients (Guilford, 1954, p. 399). The range of validity coefficients was between 0.959 and 0.994 which speaks of the intrinsic validity of the test.

ii. Content Validity

Five teachers of secondary schools teaching mathematics acted as judges in establishing content validity of the achievement test. They examined the test items, the instructions and the scoring procedure. The judges were fully satisfied with the relevance of the test items, comprehensiveness and administration procedure. They were also satisfied with the adequate coverage of the content of mathematics at IX Standard This implies that the achievement test in mathematics was found to be comprehensive and relevant.

4.4 The Sample

As pointed out earlier, the study was confined to the students of IX Standard studying in different schools of Kalghatgi taluka,

Dharwad district during the year 2001-2002. There were 15 secondary schools in the taluka in the year 2001-2002.

In these schools the number of students studying were scheduled caste – 96, scheduled tribe – 80 and general category – 965.

From the population of 15 secondary schools, 11 schools were selected at random. It may be added here that the different regions of the taluka were represented by secondary schools involved in the study. In the entire population of 1141 students, the sample of 303 students was selected using random sampling technique. The description of the sample selected for the study is given in the following table :

Table – 4.9 : Distribution of the Sample in terms of Type of School, Sex and Social Status

Types of School	Name of the School	No. of Students	No. of Students				
			Sex		Social Status		
			Boys	Girls	GM	SC	ST
Government Schools							
1	Govt. High School, Kalghatgi	30	18	12	24	5	1
2	Govt. High School, Hirehonnahalli	25	15	10	19	1	5
3	Govt. High School, Bammigatti	32	19	13	31	1	0
4	Govt High School, Devikoppa	25	13	12	19	5	1
Aided – Schools							
1	Janata English School, Kalghatagi	30	30	0	25	3	2
2	G.E.S. Girls High School, Kalaghatagi	30	0	30	24	4	2
3	S.B.B. High School, Dummawad	30	22	8	22	6	2
4	G. E. S. High School, Mishrikoti.	30	20	10	27	1	2
Unaided – Schools							
1	Sangameshwar High School, Jodalli	30	16	14	25	5	0
2	S.B G.S. High School, Kudalagi	20	14	6	15	4	1
3	Ambedkar High School, Mishrikoti	21	13	8	14	6	1
	Total	303	180	123	245	41	17

Description of the sample involved in the study when classified according to their sex and caste is given in the following table :

Table – 4.10 : Description of the Sample (n = 303)

Category	Boys	Girls	Total
Advantaged group			
General category	135	114	249
Disadvantaged group			
Scheduled Caste	20	14	34
Scheduled Tribe	14	6	20
Total	169	134	303

4.5 Prolonged Deprivation Scale (PDS)

The scale was developed by Misra, G. and Tripathi, L.B. Since measurement of the accumulated experiential content of an individual requires assessment of physical, social and personal conditions of life, prolonged deprivation was specified in terms of a number of physical, social, family, school, religious and other interactional variables. The Prolonged Deprivation Scale (PDS) consisted of 15 areas of derivation. They were: (1) housing condition, (2) home environment, (3) economic sufficiency, (4) food, (5) clothing, (6) educational experiences, (7) childhood experiences, (8) rearing experiences, (9) parental characteristics, (10) interaction with parents, (11) motivational experiences, (12) emotional experiences, (13) religious experiences, (14) travel and recreation, and (15) miscellaneous quasi-cultural experiences

The final scale consisted of 96 items to be rated on a 5 – point scale indicating the degree of prolonged deprivation. These five points of the rating scale cover values from very low degree of deprivation to (1) to very high degree of deprivation (5). A total deprivation score can be obtained through assigning numerical values to various response categories. Positive statements were scored 1, 2, 3, 4 or 5. However, the negative statements like 70, 74, 75 and 77 were scored as 5, 4, 3, 2, or 1 depending upon the response of the Ss to the statements respectively. Sum – total of all the scores represents the subject's

prolonged deprivation. In this system of scoring high score is indicative of high deprivation and low score is of low deprivation.

The stability coefficient of the scale by the test – retest method, with an interval of two month's period, was found to be 0.59 (n=40). The coefficient of consistency of the scale by the split – half method (odd vs. even items) was found to be 0.91 (n=266). Internal consistency using Kuder–Richardson formula–20 was found to be 0.92. The scale was found to be relevant and comprehensive by the judges. The intrinsic validity and construct validity of the scale were established.

The prolonged deprivation scale was administered to around 500 students, including both urban and rural students, studying in IX Standard at Kalghatgi taluka. In the scale, high score is the indication of high deprivation and low score is indication of low deprivation.

Thus, in the present study the obtained scores for all the 500 students were arranged in the descending order. About 303 students from the top with the highest deprivation scores were selected as sample.

4.6 Collection of Data

The final test on logical thinking operations in mathematics – observation, coding, inference, application and Problem-solving– was administered to 303 students of IX Standard studying in Kalghtagi

taluka The investigator personally visited Government, Aided and Un-aided secondary schools in order to collect data relating to logical thinking operations. The data were collected by administering test on logical thinking operations in mathematics in the fore–noon session and a scale on attitude toward mathematics in the after–noon session. However, the academic achievement test in mathematics was administered to the same group of students next day.

Since the purpose of the first two objectives was to study the influence of sex and caste on attainment of logical thinking operations in mathematics the related data were obtained using 'Personal Data Performa'.

4.7 Statistical Analysis of Data

As already indicated, the present study was undertaken with the main purpose of investigating the relationships between logical thinking operations (predictor variable) and the academic achievement in mathematics (criterion variable). Further, the study also aimed at determination of the relative efficiency of the predictor variables in predicting academic achievement in mathematics of IX Standard students With these purposes in view the suitable statistical techniques were selected.

In pursuance of the General Objective – 1, the 't' test was used to compare the variations in attainment of logical thinking operations

in mathematics among children belonging to SC and ST Category; ST and General Category; and SC and General Category.

In pursuance of the General Objective – 2, the 3 – way Analysis of Variance (ANOVA) was used to find the difference between boys and girls, advantaged and disadvantaged students; and students with favourable and unfavourable attitude towards mathematics.

The data were classified into categories according to different factors, sex (A) caste (B), and attitude towards mathematics (C). Accordingly, 2 X 2 X 2 factorial design was used with two levels of sex (boys and girls), two levels of caste (general category – advantaged, and SC and ST categories -- disadvantaged) and two levels of attitude (favourable and unfavourable). Thus, there were 8(2 X 2 X2) different categories into which the data were classified. The multiple comparison of means was carried out using Scheffe's test.

In pursuance of the General Objective – 3, the Pearson's Product-Moment coefficient of correlation technique was used to find the relationship between predictor variables and criterion variable. Further, the obtained 'r' values were tested for significance using 't' test.

In pursuance of the General Objective – 4, the Multiple Regression Analysis (normal) was used with the different independent variables fitted into a regression equation. This provided an indication about the relative potency of variables under consideration. The

relative contributions of the independent factors to the criterion variable was calculated by multiplying regression coefficients with the correlation coefficients and converting the same into percentages.

In pursuance of the General Objective – 5, the Path Analysis was used in order to calculate the direct and indirect effects of independent variables on dependent variable.

In pursuance of the General Objective – 6, the Principle Component Factor Analysis was used with a view to find out the combination that accounts for maximum variation when all the variables are in the linear combinations with each one as distinct identify by itself.

CHAPTER - V

ANALYSIS OF DATA AND RESULTS

Scores of students on five logical thinking operations, namely, observation, coding, inference, application, problem-solving, and marks obtained by them in the achievement test in mathematics constituted the raw data for the study. In pursuance of the objectives of the study, the data were subjected to statistical treatment. This chapter describes in detail the entire statistical analysis of data and states the results of analysis. It consists of six sections. Section–1 deals with comparison of logical thinking operations in mathematics among SC, ST and General Category students; Section–2 with simple correlations between logical thinking operations and achievement in mathematics; Section–3 with interaction effect of sex, caste and attitude on logical thinking operations in mathematics; Section–4 with multiple regression analysis; Section–5 with path analysis; and Section–6 with principle component factor analysis.

Section – 1

5.1 Comparison of Logical Thinking Operations in Mathematics among SC, ST and GC Students

In order to investigate the difference in each of the logical thinking operations in mathematics among SC, ST and General

Category students the thinking operation scores were compared using appropriate 't' test. The results are given in the following table :

Table – 5.1 : Comparison of Logical Thinking Operations in Mathematics among SC, ST and General Category Students

Operations	Caste	Mean	SD	t-value	p-value	Significance
Observation	SC ST	23.7624 27.2772	6.7601 8.2320	3.3200	< 0 01	Yes
	SC GC	23.7624 25.7921	6.7600 8.7960	1.8400	> 0.05	NS
	ST GC	27.2772 25.7921	8.2320 8.7960	1.2400	> 0.05	NS
Coding	SC ST	27.0297 27.5743	9.3540 7.5040	1.4600	> 0.05	NS
	SC GC	27.0297 25.3960	9.3540 8.6220	1 2900	> 0.05	NS
	ST GC	27.5743 25.3960	7.5040 8.6220	1.9200	> 0.05	NS
Inference	SC ST	16.8812 18.8119	8.6560 8.1290	1.9301	> 0.05	NS
	SC GC	16.8812 19.9010	8.6560 9.2190	2.4000	< 0.05	Yes
	ST GC	18.8119 19.9010	8.1290 9.2190	0.8900	> 0.05	NS
Application	SC ST	16.6337 19.6335	7.9410 9.4411	2.4601	< 0.05	Yes
	SC GC	16.6337 19.1584	7.9410 9.8760	2.0001	< 0.05	Yes
	ST GC	19.6335 19.1584	9.4411 9.8760	0.3602	> 0.05	NS
Problem-solving	SC ST	13.5149 14.2574	7.5350 8.4080	0.6600	> 0.05	NS
	SC GC	13.5149 12.5248	7.5350 7.6360	0.9300	> 0.05	NS
	ST GC	14.2574 12.5248	8.4080 7.6360	1.5300	> 0.05	NS

SC – Scheduled Caste ST – Scheduled Tribe GC – General Category

It is evident from the above table that :

1. SC and ST students differ significantly in their logical thinking operation, i.e., observation.
2. SC and General Category students do not differ significantly in their logical thinking operation, i.e., observation
3. ST and General Category students do not differ significantly in their logical thinking operation, i.e., observation
4. SC and ST students do not differ significantly in their logical thinking operation, i.e., coding.
5. SC and General Category students do not differ significantly in their logical thinking operation, i.e., coding.
6. ST and General Category students do not differ significantly in their logical thinking operation, i.e., coding
7. SC and ST students do not differ significantly in their logical thinking operation, i.e., inference.
8. SC and General Category students differ significantly in their logical thinking operation, i.e., inference.
9. ST and General Category students do not differ significantly in their logical thinking operation, i.e., inference.
10. SC and ST students differ significantly in their logical thinking operation, i.e., application.

11. SC and General Category students differ significantly in their logical thinking operation, i.e., application.
12. SC and General Category students do not differ significantly in their logical thinking operation, i.e., application.
13. SC and ST students do not differ significantly in their logical thinking operation, i.e., problem-solving.
14. SC and General Category students do not differ significantly in their logical thinking operation, i.e., problem-solving.
15. ST and General Category students do not differ significantly in their logical thinking operation, i.e., problem-solving.

It is revealed from the findings that SC and ST category students differ in their 'observation' ability; SC and General category students differ in their 'inference' ability; SC and ST students, SC and General Category students differ in their 'application' ability. When compared to students from General Category and ST category, SC students are lagging behind in the abilities like 'observation', 'inference' and 'application'. Thus, intervention programme in these abilities is essential to SC category students.

Section - 2

5.2 Simple Correlations between Logical Thinking Operations and Achievement in Mathematics

In the present study there are five logical thinking operations such as observation, coding, inference, application and problem-solving on the one hand and academic achievement in mathematics on the other hand. As a prerequisite for the in depth analysis it is essential to study the relationship between logical thinking operations and achievement in mathematics. Hence, in the present context the focus is on the study of the relationship between these variables.

The Pearson's Product-Moment Coefficient of Correlation technique was used to find the relationship between predictor variables and criterion variable. Further, the obtained 'r' values were tested for significance using 't' test. The details are given in the following paragraphs:

Table - 5.2 : Correlations of Logical Thinking Operations with Achievement in Mathematics - SC (n =101)

Operations	Achievement in Mathematics			
	'r' value	't' value	P-value	Significance
Observation	0.0530	0.5286	>0.05	NS
Coding	0.5138	5.9592	<0.01	Yes
Inference	0.3105	3.2505	<0.01	Yes
Application	0.3384	3.5782	<0.01	Yes
Problem-solving	0.2309	2.3616	<0.05	Yes

Table - 5.3 : Correlations of Logical Thinking Operations with Achievement in Mathematics - ST (n =101)

Operations	Achievement in Mathematics			
	'r' value	't' value	P-value	Significance
Observation	0.4513	5.0318	<0.01	NS
Coding	0.4786	5.4235	<0.01	Yes
Inference	0.4352	4.8098	<0.01	Yes
Application	0.2754	2.8503	<0.01	Yes
Problem solving	0.2118	2.1563	<0.05	Yes

Table - 5.4 : Correlations of Logical Thinking Operations with Achievement in Mathematics - GM (n =101)

Operations	Achievement in Mathematics			
	'r' value	't' value	P-value	Significance
Observation	0.2226	3.9618	<0.01	Yes
Coding	0.4055	7.6956	<0.01	Yes
Inference	0.3138	5.7331	<0.01	Yes
Application	0.2396	4.2820	<0.01	Yes
Problem-solving	0.1631	2.8687	<0.01	Yes

Findings

It is evident from the above table that :

i. There is a positive and significant relationship between logical thinking operations, viz., coding, inference, application, problem-solving and academic achievement in mathematics among SC category students. However, the relationship between observation and academic achievement in mathematics is not significant.

ii. There is a positive and significant relationship between logical thinking operations, viz., coding, inference, application, problem-solving and academic achievement in mathematics among ST category students. However, the relationship between observation and academic achievement in mathematics is not significant.

iii. The logical thinking operations like observation, coding, inference, application and problem-solving are positively and significantly related with academic achievement of General Category students in mathematics.

In case of Scheduled Caste and Scheduled Tribe students the correlation between logical thinking operation, i.e., observation and achievement in mathematics is not significant. This implies that the SC and ST students are lacking behind in the attainment of the ability 'observation'.

Section - 3

5.3 Interaction Effect of Sex, Caste and Attitude on Logical Thinking Operations

The scores relating to Sex, Caste and Attitude of the students towards mathematics on the one hand, and logical thinking operations - observation, coding, inference, application and problem-solving on the other hand of 303 students studying in IX Standard of Kalghatagi taluka constituted the raw data for the present study. The data were subjected to analysis in pursuance of objectives of the study and research hypotheses using Analysis of Variance (ANOVA) technique.

Constitution of Treatment Groups

The present study will have three independent factors – Sex (A), Caste (B) and Attitude (C). Factors A, B and C have a, b and c levels respectively. In the present study, Factor - A has two levels (a_1, a_2), Factor - B has two levels (b_1, b_2) and Factor – C has two levels (c_1, c_2). Here the scores on the Sex, Caste and attitude are classified into low and high groups using the 'mean' of scores of all the subjects as the criterion, i.e., cutting point. Here a_1 of Factor – A indicates boys, a_2 indicates girls; b_1 of Factor – B indicates advantaged group and b_2 indicates disadvantaged group; and c_1 of Factor – C indicates favourable attitude and c_2 indicates unfavourable attitude. Thus, in this case there will be 'abc' treatment combinations giving rise to 8 treatment groups. Each case of the sample in the study is analyzed in

terms of the above treatment combinations and the subjected are fixed into their respective groups. For the convenience of presentation, Factor – A 'Sex' has been arranged on horizontal axis and Factors-B and C, 'Caste' and 'Attitude' have been arranged in the vertical axis. Dimensionwise 'logical thinking operation' scores of each subject was placed in the appropriate cell in the table as per the above referred procedure. This forms the layout of the 2 X 2 X 2 factorial design for the present study.

Table – 5.5 : A 2 X 2 X 2 Factorial Design of Data on Logical Thinking Operations

Sex (A)		Caste (B)							
		Advantaged (b_1)				Disadvantaged (b_2)			
		Attitude (C)				Attitude (C)			
		Favourable (c_1)		Unfavourable (c_2)		Favourable (c_1)		Unfavourable (c_2)	
	Boys (a_1)	40	62	35		53	62	55	63
		42	53	42		53	62	55	65
		47	62	47		53	62	55	68
		48	63	48		55	63	57	68
		50	63	52		55	63	57	68
		50	63	55		57	65	57	72
		50	63	55		57	68	58	77
		52	63	57		57	68	58	80
		53	65	57		58	68	62	
		55	65	57		58	72	63	
		55	65	60		60	73	63	
		55	67	60		60		63	
		58	68	60		60		63	
		58	68	62		62			
		60	68	63		62			
		60	68	63					
		62	70	68					
			70	70					
	Girls (a_2)	47		35	57	48		40	53
		48		43	57	50		40	53
		50		45	60	52		42	53
		50		47	60	52		42	55
		52		47	60	52		45	55
		52		48	62	52		45	55
		53		50	62	52		47	58
		53		52	62	52		48	60
		55		52	65	55		48	62
		55		52	67	57		48	63
		55		55	68	58		48	63
		57		55	70	60		48	63
		57		55	72	60		50	65
		57		57		63		50	67
		62				65		50	75
		63				65		52	75
		65				67		53	
		65				70			
		67							
		68							
		70							
		72							

To test the research hypotheses stated in the study, 3-way Analysis of Variance technique was used.

Application of ANOVA Technique

The rationale of the analysis of variance is that the total variability of a set of measures composed of several groups, can be partitioned into specific parts, each identifiable with a given source of variation. The principle involved in the analysis of variance is the comparison of variability between the various groups with the sum of variability within the groups (Broota, 1989, p. 28).

A 3-way Analysis of Variance permits the simultaneous study of effects of three factors as well as interactions, this technique was selected for the purpose of analysis of data.

Statistical techniques generally involve assumptions that must be satisfied if the techniques are to be correctly applied. In case of ANOVA (where F-test are used) –

1. Homogeneity of variance, and
2. Normality of distribution.

are the important assumptions that are to be met before applying this technique. The reasons for considering the above mentioned assumptions underlying F-test are to confirm that the variances of scores in each of the treatment groups in the present study are homogeneous and the distribution of scores within each treatment group have been drawn from a normal population.

However, there is a good deal of evidence that the analysis of variance is virtually unaffected by violations of normality and homogeneity of variance if the samples entering into analysis are of the same or approximately the same size (Dayton, 1970, p.35).

This evidence cannot be used to escape from reporting the homogeneity of variance in the present study for the samples entering into analyses are neither of same nor of approximate in size. In such situations Dayton (1970) opines that homogeneity of variance be reported using Bartlett's Statistics (Dayton, 1970, p. 35).

Bartlett's test of Homogeneity of Variance

Bartlett's test was used for testing the homogeneity of variance with samples of the same or different sizes. Since the sample sizes (treatment groups) in the present study differ in their sizes, this test was used to test the homogeneity of variance. The formula used for finding out Bartlett's statistics in given below :

$$\chi^2 = \frac{2.303}{C}\left[\left(\sum_{j=1}^{p} n_j - p\right)\log\left(Ms_{error}\right) - \sum_{j=1}^{p}\left(n_j - 1\right)\log\left(S_j 2\right)\right]$$

where,

$$C = 1 + \frac{1}{3(P-1)}\left[\left(\sum_{j=1}^{P}\frac{1}{n_j - 1} - \frac{1}{\sum_{j=1}^{P}(n_j = 1)}\right)\right]$$

(Dayton, 1970, p. 33).

However, the computational plan for Bartlett's statistic along with calculations with reference to data on logical thinking operations are given in table below :

Table – 5.6 : Computational Plan of Bartlett's Statistics for the Data on Logical Thinking Operations

Sample	n	n-1	1/n-1	S^2	log S^2	(n-1) log S^2	MSE
1	33	32	0.0313	67 8872	1.8318	58.6172	2172.39
2	18	17	0.0588	79.4118	1.8999	32.2980	1350.00
3	27	26	0.0385	32.4440	1.5111	39.2895	843.54
4	22	21	0.0476	50.5772	1.7040	35.7831	1062.12
5	22	21	0.0476	55.1287	1.7414	36.5689	1157.70
6	27	26	0.0385	76.3374	1 8827	48.9512	1984.77
7	18	17	0.0588	44.0541	1.6440	27.9478	748.92
8	33	32	0.0313	83 386	1.9208	61.4671	2666.54
	200	192	0.3523			340.9228	11986.29

Mean Square Error : MSE = 62.4286

$$C = 1 + (1/3 \times 7)\ [0.3523 - (1/192)]$$
$$= 1 + 0.0476\ (0.3476)$$
$$= 1 + 0.0165$$
$$= 1.0165$$

$$\text{Chi-square} = (2.303/1.1065)\ [192 \times \log 62.4286 - 340.9228]$$
$$= 2.2656\ [344.7137 - 340.9228]$$
$$= 2.2656\ [3.7909]$$
$$\chi^2 = 8.5887$$

(Table value at 7 df is 14.0670)

For a total of eight variances and 2 degrees of freedom per variance, the obtained χ^2 value 8.5887 does not exceed significance (tabled χ^2 value for 7 degrees of freedom is 14.0670). Thus, the treatment groups do not differently affect the variability of the response measure, i.e., logical thinking operations.

Lilliefors Test of Normality of Distribution

Lilliefors test is a test by which the normality of treatment groups is determined(sprent, 1989, p. 235).

In order to test the second assumption of ANOVA,i.e., normality of distribution for the data on logical thinking operations test was used.

Table – 5.7 : Computational Plan of Lilliefors Test for the Data on Logical Thinking Operations

Z	X	$F_n(z)$	$\Phi(z)$	$\lvert F_n(z) - \Phi(z) \rvert$
-2.3500	1	0.0303	0.0094	0.0209

X = Single raw score of treatment group (a_1, b_1, c_1)

F_n = Proportion of observation below X.

$F_n(z)$ = Empirical distribution function

$\Phi(z)$ = Cumulative distribution function of normal distribution

$\lvert F_n(z) - \Phi(z) \rvert$ = Obtained absolute difference value

Computational Procedure

i. Standardise the data (raw scores of treatment groups) using

$$Z = \frac{X - M}{S}$$

Where ,

X = Raw score

M = Mean of the treatment group

S = The usual estimate of population, obtained from

$$S = \sqrt{\frac{\Sigma X^2 - (\Sigma X)^2 / n}{n - 1}}$$

ii. Find the cumulative standard normal value [Φ (z)] to all the Z scores

iii Find the empirical distribution function [F_n (z)] from F_n

iv. Obtain absolute difference value | $F_n(z) - \Phi(z)$ |

v. Compare the absolute difference value with table value at 1% with relevant (Sprent, 1989, p. 235)

Each 'absolute difference' value is compared with the corresponding tabled value of the related treatment group. The obtained values (treatment group wise) are given in the following tables :

Table– 5.8 : Computational Values of Lilliefors Test for Treatment Group $a_1b_1c_1$

Z	X	$F_n(z)$	$\Phi(z)$	$\mid F_n(z) - \Phi(z) \mid$
-2.3500	1	0.0303	0.0094	0.0
-2.1430	2	0.0606	0.0161	0.0209
-1.5230	3	0.0909	0.0639	0.0445
-1.3170	4	0.1212	0.0939	0.0270
-1.1100	7	0.2121	0.1335	0.0273
-0.9030	8	0.2424	0.1833	0.0786
-0.6970	9	0.2727	0.2429	0.0591
-0.4900	12	0.3636	0.3121	0.0289
-0.0770	14	0.4242	0.4693	0.0515
0.1300	16	0.4848	0.5517	0.0451
0.3370	18	0.5455	0.6319	0.0669
-0 6970	19	0.5758	0.2429	0.0864
0.3370	20	0.6061	0.6319	0.0329
0.5430	25	0.7576	0.7064	0.0258
0.7500	28	0.8485	0.7734	0.0751
0.9560	29	0.8788	0.8305	0.0483
1.1630	33	0.9300	0.8776	0.0524
1 3700	35	1.0000	0.9147	0.0853

* Critical Value = 0.1620 at 0.05 level.

Table – 5.9 : Computational Values of Lilliefors Test for Treatment Group $a_1b_1c_2$

Z	X	$F_n(z)$	Φ (z)	| $F_n(z) - \Phi(z)$ |
-2.3690	1	0.0556	0.0089	0.0467
-1 6209	2	0.1111	0.0525	0.0586
-1.0598	3	0.1667	0.1446	0.0221
-0.8728	4	0.2222	0.1914	0.0308
-0 4987	5	0.2778	0 3090	0.0312
-0.1247	7	0.3889	0.4504	0.0615
0.0623	10	0.5556	0.5248	0.0308
0.4364	13	0.7222	0.6687	0.0535
0.6234	14	0.7778	0.7335	0.0443
0.8105	16	0.8889	0.7912	0.0977
1.3715	17	0.9444	0.9149	0.0295
1 5586	18	1.0000	0.9405	0.0595

* Critical Value = 0.2000 at 0.05 level

Table–5.10 : Computational Values of Lilliefors Test for Treatment Group $a_1b_2c_1$

Z	X	$F_n(z)$	Φ (z)	| $F_n(z) - \Phi(z)$ |
-1.3790	3	0.1111	0.0839	0.0272
-1.0800	5	0.1852	0.1401	0.0451
-0.7810	8	0.2963	0.2174	0 0789
-0.4830	10	0.3704	0.3145	0.0559
-0.1840	13	0.4815	0.4270	0.0545
0.1150	18	0.6667	0.5458	0.1209
0.4140	20	0.7407	0.6606	0.0801
0.7120	21	0.7778	0.7618	0.0160
1.3100	24	0.8889	0.9049	0.0160
1.9070	25	0.9259	0.9717	0.0458
2.2060	26	0.9630	0.9863	0.0233

* Critical Value = 0.1730 at 0.05 level

Table – 5.11: Computational Values of Lilliefors Test for Treatment Group $a_1b_2c_2$

Z	X	$F_n(z)$	$\Phi(z)$	$\lvert F_n(z) - \Phi(z) \rvert$
-1.1690	3	0.1364	0.1212	0.0152
-0.9330	6	0.2727	0.1754	0.0973
-0.6970	8	0.3636	0.2429	0.1207
-0.2250	9	0.4091	0.4110	0.0019
0.0110	14	0.6364	0.5044	0.1320
0.2470	15	0.6818	0.5975	0.0843
0.7190	18	0.8182	0.7639	0.0543
1.1910	19	0.8636	0 8832	0.0196
1.9000	20	0.9091	0.9713	0.0622
2.3720	21	0 9545	0.9912	0.0367

* Critical Value 0.1900 at 0.05 level

Table – 5.12: Computational Values of Lilliefors Test for Treatment Group $a_2b_1c_1$

Z	X	$F_n(z)$	$\Phi(z)$	$\lvert F_n(z) - \Phi(z) \rvert$
-1.4999	1	0.0455	0.0668	0.0213
-1.2754	2	0.0909	0.1011	0.0102
-1.0509	4	0.1818	0.1467	0.0351
-0.8265	6	0.2727	0.2043	0.0684
-0.6020	8	0.3636	0.2736	0.0900
-0.3775	11	0.5000	0.3529	0.1471
-0.1530	14	0.6364	0.4392	0.1072
0.5204	15	0.6818	0.6986	0.0168
0.7448	16	0.7273	0.7718	0 0445
0.9693	18	0.8182	0.8338	0.0156
1 1938	19	0.8636	0.8837	0.0201
1.4182	20	0.9091	0.9219	0.0128
1.6430	21	0.9545	0.9498	0.0047
1.8670	22	1.0000	0.9690	0.0310

* Critical Value = 0.1730 at 0.05 level

Table-5.13: Computational Values of Lilliefors Test for Treatment Group $a_2b_1c_2$

Z	X	$F_n(z)$	$\Phi(z)$	$\lvert F_n(z) - \Phi(z) \rvert$
-2.4021	1	0.0370	0.0082	0.0288
-1.4483	2	0.0741	0.0738	0.0003
-1.2576	3	0.1111	0.1043	0.0068
-1.0668	5	0.1852	0.1430	0.0422
-0.8761	6	0.2222	0.1905	0.0317
-0.6853	7	0.2593	0.2466	0.0127
-0.4986	10	0.3704	0.3104	0.0600
-0.1130	13	0.4815	0.4550	0.0265
0.0770	16	0.5926	0.5310	0.0616
0.4592	19	0.7037	0.6770	0.0267
0.6500	22	0.8148	0.7422	0.0726
1.0315	23	0.8519	0.8488	0.0031
1.2220	24	0.8889	0.8891	0.0002
1.4130	25	0.9259	0.9212	0.0047
1.6040	26	0.9630	0.9456	0.0174
1.7950	27	1.0000	0.9637	0.0363

* Critical Value = 0 1610 at 0.05 level

Table–5.14: Computational Values of Lilliefors Test for Treatment Group $a_2b_2c_1$

Z	X	$F_n(z)$	Φ (z)	| $F_n(z) - \Phi(z)$ |
-1.3253	1	0.0556	0.0925	0.0369
-1.0742	2	0.1111	0.1414	0.0303
-0.8231	8	0.4444	0.2052	0.2392
-0.3209	9	0.5000	0.3741	0.1259
-0.0698	10	0.5556	0.4722	0.0834
0.1814	11	0.6111	0.5720	0.0391
0.4325	13	0.7222	0.6673	0.0549
0.9347	14	0.7778	0.8250	0.0472
1.1858	16	0.8889	0.8821	0.0068
1.4369	17	0.9444	0.9246	0.0198
1.9391	18	1.0000	0.9738	0.0262

* Critical Value = 0.2000 at 0.05 level

Table–5.15: Computational Values of Lilliefors Test for Treatment Group $a_2b_2c_2$

Z	X	$F_n(z)$	Φ (z)	| $F_n(z) - \Phi(z)$ |
-1.5048	2	0.0606	0.0662	0.0056
-1.3222	4	0.1212	0.0931	0.0281
-0.9571	6	0.1818	0.1693	0.0125
-0.7745	7	0.2121	0.2193	0.0072
-0.5920	12	0.3636	0.2769	0.0867
-0.4094	15	0.4545	0.3411	0.1134
-0.2268	16	0.4848	0.4103	0.0745
-0.0443	20	0.6061	0.4823	0.1238
0.1383	23	0.6970	0.5550	0.1420
0.5034	24	0.7273	0.6927	0.0346
0.6860	25	0.7576	0.7536	0.0040
0.8686	26	0.7879	0.8075	0.0196

Contd.....

1 0510	29	0.8788	0.8534	0.0254
1.2340	30	0.9091	0.8914	0.0177
1.4160	31	0.9394	0.9261	0.0178
2.3290	33	1.0000	0.9901	0 0099

* Critical Value = 0.1610 at 0.05 level

It is revealed from the above tables that the obtained absolute values in all the 8 treatment groups are less than the critical value in the respective group. This further implies that the entire data on logical thinking operations of all the 8 treatment groups have been drawn from their respective normal population.

Hence, the assumptions of ANOVA such as, homogeneity of variance and normality of distribution are satisfied by the present data.

Figure 1 (Contd.)

↓

Step – 4

↓

Partitioning of total degrees of freedom (df_{total})

Step – 5

↓

Compute

Mean squares of factors –

A, B, C, A X B, B X C, B X C,

A X C and A X B X C

Step – 6

↓

Compute –

'F' – ratios of factors –

A, B, C, A X B, B X C, B X C,

A X C and A X B X C

Step – 7

↓

Compare the obtained 'F' – ratios with tabled 'F' – ratios and make statistical decision (Accept/Reject Ho 's)

↓

STOP

Further, the analysis of the interaction effect of sex, caste and attitude on logical thinking operations – observation, coding,

inference, application, and problem solving are given in the following sections.

Interaction Effect of Sex, Caste and Attitude on Logical Thinking Operation – Observation

In the analysis factors A, B, and C represents the variables like Sex, Caste, and Attitude respectively. These variables have two levels each sex (boys and girls), caste (advantaged and disadvantaged), and attitude (favourable and unfavourable). The scores on the logical thinking operations – observation were used for analysis. The summary table of analysis of variance is given below :

Table – 5.16 : Summary Table of ANOVA with Respect to Logical Thinking Operation – Observation

Source of Variation	df	Sum of Squares	Mean Squares	F-ratio	Significance
Main Effects					
A (Sex)	1	33.0324	33.0324	0.5171	NS
B (Caste)	1	1.1934	1.1934	0 0187	NS
C (Attitude)	1	137.7904	137.7904	2.1572	NS
2-way Interaction					
A X B	1	89.7818	89.7818	1.4056	NS
A X C	1	23.3607	23.3607	0.3657	NS
B X C	1	0.7273	0.7273	0.0114	NS
3-way Interaction					
A X B X C	1	73.2948	73 2948	1.1475	NS
Error	295	63.8757	0.216		
Total	302	423			

Note : NS – Not Significant

Findings

The analysis of the above table reveals the following :

1. Boys and girls do not differ significantly in respect of their logical thinking operation–observation.

2. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation observation.

3. Students with favourable and unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–observation.

4. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation–observation.

5. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–observation.

6. Advantaged/Disadvantaged students with favourable/ unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–observation.

7. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–observation.

Interaction Effect of Sex, Caste and Attitude on Logical Thinking Operation – Coding

The summary table of analysis of variance is given below.

Table – 5.17 : Summary Table of ANOVA with Respect to Logical Thinking Operation – Coding

Source of Variation	df	Sum of Squares	Mean Squares	F-ratio	Significance
Main Effects					
A (Sex)	1	1.5848	1.5848	0.0229	NS
B (Caste)	1	0.0388	0.0388	0.0006	NS
C (Attitude)	1	641.3737	641.3737	9.2838	Yes
2-way Interaction					
A X B	1	444.3587	444.3587	6.4320	Yes
A X C	1	406.8508	406.8508	5.8891	Yes
B X C	1	405.0804	405.0804	5.8635	Yes
3-way Interaction					
A X B X C	1	217.6228	217.6228	3.1501	Yes
Error	295	69.0853	0.2340		
Total	302	2186			

Findings

The analysis of the above table reveals the following :

1. Boys and girls do not differ significantly in respect of their logical thinking operation – coding.

2. Advantaged/disadvantaged students do not differ significantly in respect of their logical thinking operation – coding.

3. Students with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation – coding.

However, the means of favourable and unfavourable attitude towards mathematics are 27.77 and 25 39 respectively. Since the two means clearly reveals that favourable attitude towards mathematics has a greater mean than the mean of unfavourable attitude towards mathematics it can be interpreted that students with favourable attitude towards mathematics in greater number attain logical thinking operation 'coding' than those with unfavourable attitude towards mathematics.

4. Boys/Girls with advantaged/disadvantaged background differ significantly in respect of their logical thinking operation – coding.

However, it is not clear from the above finding that which of the comparisons of the treatment groups differ significantly. To know this, comparison of means of all the treatment groups was carried out using Scheffes test (1953). The findings are shown in the following table.

Table – 5.18 : Scheffe's Multiple Comparison of Means for 'Coding' (Sex X Caste)

Sl. No.	Comparison of Treatment Groups	Corresponding Means	Simultaneous Confidence Intervals	Significance at 0.05 level
1	$a_1\, b_1$ & $a_2\, b_1$	25.9801 & 30.5010	3.1976 ; 5.8442	Yes
2	$a_2\, b_1$ & $a_2\, b_2$	30.5010 & 25.7379	3.4398 ; 6.0864	Yes

Note : 1. The mean values of the other treatment groups are not significant.
2. Higher the difference in mean scores implies significant difference.

The analysis of the above table reveals the following :

1. As the simultaneous confidence interval values of S. No. 1 are in the same direction, i.e. 3.1976 & 5.8442, the difference is significant. Hence, the means of the treatment groups a_1 b_1 (25.9801) and a_2b_1 (30.5010) differ significantly in respect of their logical thinking operation–coding. However, the observation of two means clearly indicates that the mean value of the treatment group a_2 b_1 is greater than the mean value of the treatment group a_1b_1. This further implies that girls with advantaged background are better in their logical thinking operation 'coding' than the boys with advantaged background.

2. As the simultaneous confidence intervals of S. No. 2 are in same direction, i.e., 3.4398 & 6.0864 the difference is significant. Hence, the means of the treatment groups a_2b_1 (30.5010) and a_2b_2 (25.7379) differ significantly in respect of their logical thinking operation – coding. However, the observation of two means clearly indicates that the mean value of the treatment group a_2b_1 is greater than the mean value of the treatment group a_2b_2. This further implies that girls with advantaged background are better in their logical thinking operation 'coding' than the girls with disadvantaged background

5. Boys/Girls with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation – coding.

However, the multiple comparison of means using Scheffe's test was further carried out in order to find out the treatment groups which differ significantly. The findings are given in the following table.

Table – 5.19 : Scheffe's Multiple Comparison of Means 'Coding' (Sex X Attitude)

Sl. No.	Comparison of Treatment Groups	Corresponding Means	Simultaneous Confidence Intervals	Significance
1	a_1c_1 & a_1c_2	33.5956 & 23.2179	9.0543 ; 11.7010	Yes
2	a_1c_1 & a_2c_1	33.5956 & 28.7075	3.5643 ; 6.2109	Yes
3	a_1c_1 & a_2c_2	33.5956 & 27.5317	4.7405 ; 7.3871	Yes
4	a_1c_2 & a_2c_1	23.2179 & 28.7075	4.1663 ; 6.8129	Yes
5	a_1c_2 & a_2c_2	23.2179 & 27.5317	2.9905 ; 5.6371	Yes

Note . The mean values of the other treatment groups are not significant

The analysis of the above table reveals the following :

1. As the simultaneous confidence interval values of S. No. 1 are in the same direction, i.e., 9.0543 & 11.7010 the difference is significant. Hence, the means of the treatment groups a_1c_1 (33.5956) and a_1c_2 (23.2179) differ significantly in respect of their logical thinking operation – coding. However, observation of two means clearly indicates that the mean value of the treatment group a_1c_1 is greater than the mean value of the treatment group a_1c_2. This further implies that boys with the favourable attitude towards mathematics are better in their 'coding' ability than the boys with unfavourable attitude.

2. As the simultaneous confidence intervals of S. No. 2 are in the same direction, i.e., 3.5643 & 6.2109 the difference is significant. Hence, the means of the treatment groups a_1c_1 (33.5956) and a_2c_1 (28.7075) differ significantly in respect of their logical thinking operation – coding. However, observation of two means clearly indicates that the mean value of the treatment group a_1c_1 is greater than the mean value of the treatment group a_2c_1. This further implies that boys with the favourable attitude towards mathematics are better in their 'coding' ability than the girls with unfavourable attitude.

3. As the simultaneous confidence intervals of S. No. 3 are in the same direction, i.e., 4.7405 & 7.3871 the difference is significant. Hence, the means of the treatment groups a_1c_1 (33.5956) and a_2c_2 (27.5317) differ significantly in respect of their logical thinking operation – coding. However, observation of two means clearly indicates that the mean value of the treatment group a_1c_1 is greater than the mean value of the treatment group a_2c_2. This further implies that boys with the favourable attitude towards mathematics are better in their 'coding' ability than the girls with unfavourable attitude.

4. As the simultaneous confidence intervals of S. No. 4 are in the same direction, i.e., 4.1663 & 6.8129 the difference is significant. Hence, the means of the treatment groups a_1c_2 (23.2179) and a_2c_1 (28.7075) differ significantly in respect of their logical thinking operation – coding. However, observation

of two means clearly indicates that the mean value of the treatment group a_2c_1 is greater than the mean value of the treatment group a_1c_2. This further implies that girls with the favourable attitude towards mathematics are better in their 'coding' ability than the boys with unfavourable attitude

5. As the simultaneous confidence intervals of S. No. 5 are in the same direction, i.e., 2.9905 & 5.6371 the difference is significant. Hence, the means of the treatment groups a_1c_2 (23.2179) and a_2c_2 (27.5317) differ significantly in respect of their logical thinking operation – coding. However, observation of two means clearly indicates that the mean value of the treatment group a_2c_2 is greater than the mean value of the treatment group a_1c_2. This further implies that girls with the favourable attitude towards mathematics are better in their 'coding' ability than the boys with unfavourable attitude.

6. Boys/Girls with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation – coding.

However, the multiple comparison of means using Scheffe's test reveals the following :

Table - 5.20 : Scheffe's Multiple Comparison of Means 'Coding' (Caste X Attitude)

Sl. No.	Comparison of Treatment Groups	Corresponding Means	Simultaneous Confidence Internal	Significance
1	b_1c_1 & b_2c_2	28.8336 & 33.4693	3.3124; 5.9590	Yes
2	b_1c_2 & b_2c_1	27.6473 & 23.1099	4.4004; 7.0470	Yes
3	b_1c_1 & b_2c_1	28.8336 & 33.4693	4.4986; 7.1452	Yes
4	b_1c_2 & b_2c_1	27.6473 & 23.1019	3.2225; 5.8691	Yes
5	b_2c_2 & b_2c_1	33.4693 & 23.1019	9.0441; 11.6910	Yes

Note : The mean values of the other treatment groups are not significant.

The analysis of the above table reveals the following :

i. The mean of the treatment group b_1c_1 (28.8336) is lesser than the mean of the treatment group b_2c_2 (33.4693). This implies that students from advantaged background with unfavourable attitude are better in 'coding' ability than the students from disadvantaged background with favourable attitude.

ii. The mean of the treatment group b_1c_2 (27.6473) is greater than the mean of the treatment group b_2c_1 (23.1099). This implies that students from advantaged background with unfavourable attitude is better in 'coding' ability than the students from disadvantaged background with favourable attitude.

iii. The mean of the treatment group b_1c_1 (28.8336) is lesser than the mean of the treatment group b_2c_1 (33.4693). This shows that students from advantaged background with favourable attitude are

better in 'coding' ability than the students from disadvantaged background with favourable attitude.

iv. The mean of the treatment group b_1c_2 (27.6477) is greater than the mean of the treatment group b_2c_2 (23.1019). This shows that students from advantaged background with unfavourable attitude are better in 'coding' ability than students from disadvantaged background with unfavourable attitude.

v. The mean of the treatment group b_2c_1 (33.4693) is greater than the mean of the treatment group b_2c_2 (23.1019). This indicates that students from disadvantaged background with favourable attitude are better in 'coding' ability than students from disadvantaged background with unfavourable attitude.

7. Boys/Girls from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation–coding

However, the multiple comparison of means using Scheffe's test reveals the following :

Table – 5.21 : Scheffe's Multiple Comparison of Means – 'Coding' (Sex X Caste X Attitude)

Sl. No.	Comparison of Treatment Groups	Corresponding Means	Simultaneous Confidence Internal	Significance
1	$a_1b_1c_1$&$a_1b_2c_1$	27.1910 & 40.000	11.4860; 14.1320	Yes
2	$a_1b_1c_2$&$a_1b_2c_1$	24.7600 & 40.000	13.9170; 16.5630	Yes
3	$a_1b_2c_1$&$a_1b_2c_2$	40.0000 & 21.6667	17.0100; 19.6560	Yes
4	$a_1b_2c_1$&$a_2b_1c_2$	40.0000 & 30.4761	8.2006; 10.8470	Yes
5	$a_1b_2c_1$&$a_2b_1c_2$	40.0000 & 30.5263	8.1504; 10.7970	Yes
6	$a_1b_2c_1$&$a_2b_2c_1$	40.0000 & 26.9388	11.7380; 14.3840	Yes
7	$a_1b_2c_1$&$a_2b_2c_2$	40.0000 & 24.5370	14.1400; 16.7860	Yes
8	$a_1b_2c_2$&$a_2b_1c_1$	21.6667 & 30.4761	7.4861; 10.1333	Yes
9	$a_1b_2c_2$&$a_2b_1c_2$	21.6667 & 30.5263	7.5363; 10.1830	Yes

Note : The mean values of the other treatment groups are not significant.

It is revealed from the above table that the mean values of the treatment groups $a_1b_1c_1$, $a_1b_1c_2$, $a_1b_2c_1$, $a_1b_2c_2$ differ significantly from their corresponding groups $a_1b_2c_1$, $a_1b_2c_1$, $a_2b_1c_2$, $a_2b_1c_2$, $a_2b_1c_1$, $a_2b_1c_2$, $a_2b_2c_1$, $a_2b_2c_2$, $a_2b_1c_1$ and $a_2b_1c_2$ in their logical thinking operations–coding as their simultaneous confidence intervals are in the same direction.

However, the observation of means of these groups clearly reveals the following :

i. The mean of the treatment group $a_1b_1c_1$ (27.1910) is lesser than the mean of the treatment group $a_1b_2c_1$ (40.000). This implies that boys from disadvantaged background with favourable attitude are better in 'coding' ability than the boys from advantaged background with favourable attitude towards mathematics.

ii. The mean of the treatment group $a_1b_1c_2$ (24.7600) is lesser than the mean of the treatment group $a_1b_2c_1$ (40.000). This implies that boys from disadvantaged background with favourable attitude are better in 'coding' ability than the boys from advantaged background with unfavourable attitude

iii. The mean of the treatment group $a_1b_2c_1$ (40.000) is greater than the mean of the treatment group $a_1b_2c_2$ (21.667). This shows that boys from disadvantaged background with favourable attitude are better in coding than the boys from disadvantaged background with unfavourable attitude.

iv. The mean of the treatment group $a_1b_2c_1$ (40.000) is greater than the mean of the treatment group $a_2b_1c_1$ (30.4761). This indicates that boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from advantaged background with favourable attitude.

v. The mean of the treatment group $a_1b_2c_1$ (40.000) is greater than the mean of the treatment group $a_2b_1c_2$ (30.5263). This shows that boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from advantaged background with unfavourable attitude.

vi. The mean of the treatment group $a_1b_2c_1$ (40.000) is greater than the mean of the treatment group $a_2b_2c_1$ (23.9388). This indicates that boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from

disadvantaged background with favourable attitude.

vii. The mean of the treatment group $a_1b_2c_1$ (40.000) is greater than the mean of the treatment group $a_2b_2c_2$ (24.5370). This shows that boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from disadvantaged background with unfavourable attitude.

viii. The mean of the treatment group $a_1b_2c_2$ (21.6667) is lesser than the mean of the treatment group $a_2b_1c_1$ (30.4761). This shows that boys from disadvantaged background with unfavourable attitude are lacking in 'coding' ability when compared to girls from advantaged background with favourable attitude.

ix. The mean of the treatment group $a_1b_2c_2$ (21.6667) is lesser than the mean of the treatment group $a_2b_1c_2$ (30.5263). This shows that girls from advantaged background with unfavourable attitude are better in 'coding' ability than the boys from disadvantaged background with unfavourable attitude.

Interaction Effect of Sex, Caste and Attitude on Logical Thinking Operation – Inference

The summary table of analysis of variance is given below.

Table – 5.22 : Summary Table of ANOVA with Respect to Logical Thinking Operation – Inference

Source of Variation	df	Sum of Squares	Mean Squares	F-ratio	Significance
Main Effects					
A (Sex)	1	70.061	70.061	0.9203	NS
B (Caste)	1	1.941	1.941	0.0255	NS
C (Attitude)	1	104.288	104.288	1.3699	NS
2-way Interaction					
A X B	1	4.346	4.346	0.0571	NS
A X C	1	20.529	20.529	0.2697	NS
B X C	1	116.573	116.573	1.5313	NS
3-way Interaction					
A X B X C	1	120.868	120.868	1.5877	NS
Error	295	76.1276	0.2580		
Total	302	515			

Note – NS – Not Significant

Findings

The analysis of the above table reveals the following :

1. Boys and Girls do not differ significantly in respect of their logical thinking operation – Inference.

2. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation – Inference.

3. Students with favourable and unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation-Inference.

4. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation – Inference.

5. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–Inference.

6. Advantaged/disadvantaged students with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation – Inference.

7. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–Inference.

Interaction Effect of Sex, Caste and Attitude on Logical Thinking Operation – Application

The summary table of analysis of variance is given below :

Table – 5.23 : Summary Table of ANOVA with Respect to Logical Thinking Operation – Application

Source of Variation	df	Sum of Squares	Mean Squares	F-ratio	Significance
Main Effects					
A (Sex)	1	[illegible]	12.1668	0.1466	NS
B (Caste)	1	[illegible]	32.0147	0.3858	NS
C (Attitude)	1	[illegible]	651.7938	7.8546	Yes
2-way Interaction					
A X B	1	[illegible]	32.7266	0.3944	NS
A X C	1	163.2508	163.2508	1.9673	NS
B X C	1	[illegible]	175.1986	2.1113	NS
3-way Interaction					
A X B X C	1	463.2953	463.2953	5.5831	Yes
Error	[illegible]	[illegible]	0.2812		
Total	[illegible]	1613			

Findings

The analysis of the above table reveals the following :

1. Boys and Girls do not differ significantly in respect of their logical thinking operation – Application.

2. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation – Application

3. Students with favourable and unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation Application.

However, the observation of two means, of favourable and unfavourable attitude groups clearly indicates that the mean of the treatment group favourable attitude (21.3975) is greater than the mean of the unfavourable attitude group (17.6596). This further implies that students with favourable attitude towards mathematics are better in the logical thinking operation Application than the students with unfavourable attitude towards mathematics.

4. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation – Application.

5. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–Application.

6. Advantaged/disadvantaged students with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation–Application.

7. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation–Application.

Further comparison of means was carried out using Scheffe's test in order to identify the pairs of treatment group which differ in their logical thinking operation - Application.

The summary table of the Scheffe's comparison of means with regard to application is given below

Table - 5.24 : Scheffe's Multiple Comparison of Means–Application (Sex X Caste X Attitude)

Sl. No	Comparison of Treatment Groups	Corresponding Means	Simultaneous Confidence Internal	Significance
1	$a_1b_1c_1$ & $a_1b_2c_1$	17.8098 & 28.3330	9.0738; 11.9780	Yes
2	$a_1b_1c_2$ & $a_1b_2c_1$	17.0000 & 28.3330	9.8827; 12.7820	Yes
3	[illegible]	28.3330 & 17.1052	9.7775; 12.6780	Yes
4	[illegible]	28.3330 & 20.0000	6.8877; 9.7823	Yes
5	[illegible]	28.3330 & 18.9815	7.9012; 10.8020	Yes
6	[illegible]	11.6667 & 21.9047	8.7874; 11.6880	Yes
7	[illegible]	11.6667 & 20.0000	6.8827; 9.7833	Yes

Note The mean values of the other treatment groups are not significant.

Findings

The analysis of the above table reveals the following :

1. The mean value off the treatment group $a_1b_1c_1$, (17.8098) is lesser than the mean value of $a_1b_2c_1$ (28.3330). This implies that boys from disadvantaged background with favourable attitude are better in their logical thinking operation - application than the boys from advantaged background with favourable attitude.

2. The mean value of the treatment group $a_1b_1c_2$ (17.000) is lesser than the mean value of $a_1b_2c_1$

(28.3330). This implies that boys from disadvantaged background with favourable attitude are better in their logical thinking operation – application than the boys from advantaged background with unfavourable attitude.

3. The mean value of the treatment group $a_1b_2c_1$, (28.3330) is greater than the mean value of $a_2b_1c_2$ (17.1052) This implies that boys from disadvantaged background with favourable attitude are better in their logical thinking operation – application than the girls from advantaged background with unfavourable attitude.

4. The mean value of the treatment group $a_1b_2c_1$, (28.3330) is greater than the mean value of $a_2b_2c_1$ (20.0000). This implies that boys from disadvantaged background with favourable attitude are better in their logical thinking operation – application than the girls from disadvantaged background with favourable attitude.

5. The mean value of the treatment group $a_1b_2c_1$ (28.3330) is greater than the mean value of $a_2b_2c_1$ (18.9815). This implies that boys from disadvantaged background with favourable attitude are better in their logical thinking operation - application than the girls from disadvantaged background with favourable attitude.

6. The mean value of the treatment group $a_1b_2c_2$, (11.6667) is lesser than the mean value of $a_2b_1c_1$ (21.9047). This implies that girls from advantaged background with favourable attitude are better in

their logical thinking operation - application than the boys from disadvantaged background with unfavourable attitude

7. The mean value of the treatment group $a_1b_2c_2$ (11.6667) is lesser than the mean value of $a_2b_2c_1$ (20.000). This implies that girls from disadvantaged background with favourable attitude are better in their logical thinking operation – application than the boys from disadvantaged background with unfavourable attitude.

Interaction Effect of Sex, Caste and Attitude on Logical Thinking Operation – Problem Solving

The summary table of analysis of variance is given below.

Table - 5.25 : Summary Table of ANOVA with Respect to Logical Thinking Operation – Problem - Solving

Source of Variation	df	Sum of Squares	Mean Squares	F ratio	Significance
Main Effects					
A (Sex)	1	1.1364	1.1364	0.0183	NS
B (Caste)	1	30.4264	30.4264	0.4909	NS
C (Attitude)	1	112.9771	112.9771	1.8227	NS
2-way Interaction					
A X B	1	34.2251	34.2251	0.5522	NS
A X C	1	1.1543	1.1543	0.0186	NS
B X C	1	57.0159	57.0159	0.9199	NS
3-way Interaction					
A X B X C	1	99.4557	99.4557	1.6046	NS
Error	295	61.9817	0.210		
Total	302	398			

Note – NS = Not Significant

Findings

The analysis of the above table reveals the following :

1. Boys and girls do not differ significantly in respect of their logical thinking operation - problem-solving.

2. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation - problem solving.

3. Students with favourable and unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation - problem-solving.

4. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation - problem-solving.

5. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation - problem-solving.

6. Advantaged/Disadvantaged Students with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation - problem-solving.

7. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation – problem-solving.

5.4 Multiple Regression Analysis

The significant zero order correlations between logical thinking operations of students on one hand, and their academic achievement in Mathematics on the other, cannot be taken to be final and ultimate. This can be due to the zero order correlation between any two variables being their common dependence upon a third variable or several other variables.

The most commonly used procedure in the prediction of a continuous criterion variable is the multiple linear regression model (Guilford, 1965). Weights known as regression coefficients are determined for each predictor variable. The resulting sum of squares on the composite of these variables will show the highest possible relationship (multiple correlation) with the criterion variable.

In order to determine the total and relative contributions of the different logical thinking operations in bringing about desirable changes in the academic achievement in mathematics of the students studying in secondary schools, multiple regression analysis technique was used.

In this method, multiple correlations and multiple linear regressions reveal the degree to which each independent variable is related to academic achievement (criterion). The product of β value with correlation coefficient of the respective criterion variable with the

predictor variable reveals the extent to which the respective predictor variable contributes towards the determination of the variation in the criterion variable under the conditions of linearity. Often this contribution is expressed in percentage with the square of the multiple correlation coefficient also being expressed in percentage.

Regression coefficients and multiple correlations reveal the degree to which each independent variable is related to academic achievement in mathematics, while the effect of all other independent variables is controlled. To identify this type of relationship between five logical thinking operations on the one hand, and the academic achievement in mathematics on the other hand, the multiple correlation and multiple regression analysis were carried out.

The procedure used in determining the relative contributions of the five logical thinking operations in bringing about variance in the academic achievement of mathematics in Scheduled Caste students is described below :

Criterion – Academic Achievement in Mathematics among SC Students

The regression co-efficients obtained for the five logical thinking operations are shown in the following table :

Table – 5.26 : Regression Coefficient and Multiple Correlations between Logical Thinking Operations and Academic Achievement in Mathematics (SC)

Predictors	Reg. Coefficient	SE of Coefficient	't' Value	P-Value	Significance
Observation (X_1)	-0.0479	0.0863	-0.5544	0.5806	NS
Coding (X_2)	0.4164	0.0952	4.3758	0.0000	Yes
Inference (X_3)	0.1427	0.0937	1.5221	0.1313	NS
Application (X_4)	0.0998	0.1001	0.9969	0.3214	NS
Problem – solving (X_5)	0.1427	0.0868	1.6439	0.1035	NS
R	0.5678				
F-Value	9.0419, P<0 01, Significant				
SE_{est}	0.8445				

The regression equation predicting total academic achievement in mathematics (Y_2) turned out to be :

$$Y_2 = 0.00 - 0.0479(X_1) + 0\ 4164(X_2) + 0.1427(X_3) + 0.0998(X_4) + 0.1427(X_5)$$

The multiple R of the regression equation is 0.5678. For testing the multiple correlation coefficient the F ratio (9.0419) was found to be significant at 0.01 level. Therefore, the corresponding null hypothesis is rejected. Thus, the significance of R suggests that estimation of academic achievement in mathematics is possible on the basis of five logical thinking operations, viz , observation, coding, inference, application and problem–solving. Further, the regression equation shows that coding has greater impact (0.4164) than all other predictors. Logical thinking operations like observation, coding, inference, application, and problem–solving can be used to predict academic achievement in mathematics with the coefficient of multiple

determination R^2 as 0.322. It can, therefore, be said that 32.2 percent of the variation in the academic achievement in mathematics can be accounted by the five logical thinking operations.

The SE_{est} for the regression equation is 0.8445. This means that each time the regression equation the sample is used to predict total adjustment the chances are about 1 in 100 that predicted total academic achievement in mathematics that will not miss the actual total academic achievement in mathematics of SC category students by more than ± 0.8445.

The index of forecasting efficiency ($E = 1 - \sqrt{1 - R^2}$) was found to be 17.66. This means that predictions by the means of regression equation is 17.66 per cent better than those made merely from a knowledge of the mean of the (Y_2) values.

Negative regression coefficient associated with X_1, may be attributed to the fact that it has zero correlation with criterion, but high correlations with valid predictors. Such a variable is called a 'suppressor variable'. It increases the multiple correlation by (suppressing) some of the invalid variance of the valid predictors (Dubois, 1965).

The relative contributions of the five logical thinking operations in terms of variance predicted by each are given by the corresponding values and are given in the following table :

Table – 5.27 : Relative Contributions of the Five Logical Thinking Operations in Predicting Academic Achievement in Mathematics in SC Category

Predictors	'β' Values	'r' Values	β x r	% of Contribution
Observation (X_1)	-0.0479	0.5300	-0.00254	-0.254
Coding (X_2)	0.4164	0.5138	0.21394	21.395
Inference (X_3)	0.1427	0.3105	0.04430	4.430
Application (X_4)	0.0998	0.3384	0.03377	3.377
Problem – solving (X_5)	0 1427	0.2309	0.03294	3.295
Total				32.243

From the above table it is evident that in case of SC category students about –0.254% of the criterian variable is accounted for by variance in the observation, about 21.395% by the coding, about 4.430% by the inference, about 3.377% by the application and 3.295% by the problem–solving. Thus, coding seems to be the best predictor of all the predictor variables, the next best predictors of total academic achievement in mathematics in the order of priority are inference, application and problem-solving, whereas observation has suppressing effect on the academic achievement in mathematics among SC category students.

Criterion – Academic Achievement in Mathematics among ST students

The regression coefficients obtained for the five logical thinking operations for ST category students are shown in the following table :

Table – 5.28 : Regression Coefficient and Multiple Correlations between Logical Thinking Operations and Academic Achievement in Mathematics (ST)

Predictors	Reg. Coefficient	SE of Coefficient	't' Value	P-Value	Significance
Observation (X_1)	0.2508	0.0868	2.8903	0.0048	Yes
Coding (X_2)	0.3436	0.0865	3.9733	0.0001	Yes
Inference (X_3)	0.3906	0.0870	4.4909	0.0000	Yes
Application (X_4)	-0.1052	0.0938	-1.1219	0.2647	NS
Problem – solving (X_5)	0.1170	0 0816	1 4344	0.1547	NS
R	0.6659				
F-Value	15.1390, P<0.01, Significant				
SE_{est}	0.7654				

The regression equation predicting total academic achievement in mathematics (Y_2) turned out to be :

$$Y_2 = 0.00 + 0.2508(X_1)+0.3436(X_2)+0.3906(X_3) - 0.1052(X_4)+0.1170(X_5)$$

The multiple R of the regression equation is 0 6659. For testing the multiple correlation coefficient the F ratio (15.1390) was found to be significant at 0.01 level. Therefore, the corresponding null hypothesis is rejected. Thus, the significance of R suggests that estimation of academic achievement in mathematics is possible on the basis of five logical thinking operations, viz., observation, coding inference, application and problem–solving. Further, the regression equation shows that inference has greater impact (0.3906) than all other predictors. Logical thinking operations like observation, coding inference, application and problem–solving can be used to predict academic achievement in mathematics with the coefficient of multiple

determination R^2 as 0.443. It can, therefore, be said that 44.3 per cent of the variation in the academic achievement in mathematics can be accounted by the five logical thinking operations.

The SE_{est} for the regression equation is 0.7654. This means that each time the regression equation for the sample is used to predict total adjustment the chances are about 1 in 100 that predicted total academic achievement in mathematics that will not miss the actual total academic achievement in mathematics of ST category students by more than ± 0.7654.

The index of forecasting efficiency ($E = 1 - \sqrt{1 - R^2}$) was found to be 25.37. This means that predictions by the means of regression equation is 25.37 per cent better than those made merely from a knowledge of the mean of the (Y_2) values.

Negative regression coefficient associated with X_4 may be attributed to the fact that it has zero correlation with criterion, but high correlations with valid predictions. Such a variable is called a 'Suppressor Variable'. It increases the multiple correlation by (suppressing) some of the invalid variance of the valid predictors (Dubois, 1965).

The relative contributions of the five logical thinking operations in term of variance predicted by each are given by the corresponding values and are given in the following table :

Table – 5.29 : Relative Contributions of the Five Logical Thinking Operations in Predicting Academic Achievement in Mathematics in ST Category

Predictors	'β' Values	'r' Values	β X r	% of Contribution
Observation (X_1)	0.2508	0.4513	0.11319	11.319
Coding (X_2)	0.3436	0.4786	0.16445	16.445
Inference (X_3)	0.3906	0.4352	0.16999	16.999
Application (X_4)	0.1052	-0.2754	-0.02897	-2.897
Problem-solving (X_5)	0.1170	0.2118	0.02478	2.478
	Total			44.344

From the above table, it is evident that in case of ST category students about – 2.897% of the criterion variable is accounted for by variance in the application, about 16.999% by the inference, about 16.445% by the coding, about 11.319% by the observation and 2.478% by the problem–solving. Thus, inference seems to be the best predictor of all the predictor variables ; the next best predictors of the total academic achievement in mathematics in the order of priority are coding, observation and problem–solving, whereas application has suppressing effect on the academic achievement in mathematics among ST category students.

Criterion – Academic Achievement in Mathematics among General Category Students

The regression coefficients obtained for the five logical thinking operations for General Category students are shown in the following table :

Table – 5.30 : Regression Coefficient and Multiple Correlations between Logical Thinking Operations and Academic Achievement in Mathematics (GM)

Predictors	Reg. Coefficient	SE of Coefficient	't' Value	P-Value	Significance
Observation (X_1)	0.0736	0.0547	1.3452	0.1796	NS
Coding (X_2)	0.3289	0.0557	5.9022	0.0000	Yes
Inference (X_3)	0.2334	0.0584	3.9974	0 0001	Yes
Application (X_4)	-0.0066	0.0615	-0.1076	0.9143	NS
Problem – solving (X_5)	0.0521	0.0531	0.9817	0.3270	NS
R	0.4795				
F-Value	17.7310, P < 0.01, Significant				
SE_{est}	0.8849				

The regression equation predicting total academic achievement in mathematics (Y_2) turned out to be :

$$Y_2 = 0.00 + 0.0736(X_1)+0.3289(X_2)+0.2334(X_3) - 0.0066(X_4)+0.0521(X_5)$$

The multiple R of the regression equation is 0.4795. For testing the multiple correlation coefficient the F ratio (17.7310) was found to be significant at 0.01 level. Therefore, the corresponding null hypothesis is rejected. Thus, the significance of R suggests that estimation of academic achievement in mathematics is possible on the basis of the five logical thinking operations, viz., observation, coding, inference, application and problem–solving. Further, the regression equation shows that coding has greater impact (0.3289) than all other predictors. Logical thinking operations like observation, coding, inference, application and problem–solving can be used to predict academic achievement in mathematics with the coefficient of multiple

determination R^2 as 0.229. It can, therefore, be said that 22.9 per cent of the variation in the academic achievement in mathematics can be accounted by the five logical thinking operations.

The SE_{est} for the regression equation is 0.8849. This means that each time the regression equation for the sample is used to predict total adjustment the chances are about 1 in 100 that predicted total academic achievement in mathematics that will not miss the actual total academic achievement in mathematics of General Category students by more than ± 0.8849.

The index of forecasting efficiency ($E = 100\ (1-\sqrt{1-R^2})$ was found to be 12.25. This means that predictions by the means of regression equation is 12.25 per cent better than those made merely from the knowledge of the mean of the Y_2 values.

Negative regression coefficient associated with X_4 may be attributed to the fact that it has zero correlation with criterion, but high correlations with valid predictors. Such a variable is called a 'suppressor variable'. It increases the multiple correlation by (suppressing) some of the invalid variance of the valid predictors (Dubois, 1965).

The relative contributions of the five logical thinking operations in terms of variance predicted by each are given by the corresponding values and are given in the following table :

Table – 5.31: Relative Contributions of the Five Logical Thinking Operations in Predicting Academic Achievement in Mathematics in General Category

Predictors	'β' Values	'r' Values	β x r	% of Contribution
Observation (X_1)	0.0736	0.2226	0.01638	1.638
Coding (X_2)	0.3289	0.4055	0.13337	13.337
Inference (X_3)	0.2334	0.3138	0.07324	7 324
Application (X_4)	-0.0066	0.2396	-0.00158	-0.158
Problem – solving (X_5)	0.0521	0.1631	0.00849	0.849
	Total			22.99

From the above table, it is evident that in case of General Category students about – 0.158% of the criterion variable is accounted for by variance in the application, about 13.337% by the coding, about 7.324% by the inference, about 1.638% by the observation and 0.849% by the problem–solving. Thus, coding seems to be the best predictor of all the predictor variables; the next best predictors of total academic achievement in mathematics in the order of priority are inference, observation and problem–solving, whereas application has suppressing effect on the academic achievement in mathematics among General Category students.

Section – 5

5.5 Path Analysis

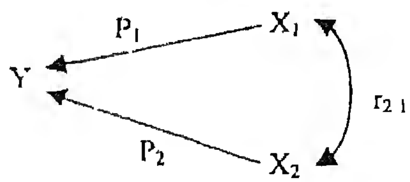
In simple, multiple and multivariate regression analysis, emphasis was on the study of the extent to which the dependent variable(s) get affected by the contribution of the independent variable(s) on original scale of measurement being standardized for comparison of the scores with the studies being carried out by others with the same variable(s). The regression coefficients obtained by carrying out simple, multiple or multivariate regression analysis were found to get affected by the unit of scale of measurement. In other words, the values of the regression coefficients of the variables get altered with the change of unit of measurement of the variable(s). In order to understand the true relation between the dependent and independent variables it becomes necessary to have regression coefficients independent of the unit of measurement of the variables. This is achieved by both the dependent and independent variables being standardized as : $Z = \frac{X-\mu}{\sigma}$ with μ and σ being the mean and the standard deviation of the variable X : It is evident that the standardized variable Z has mean Zero (0) and variance one (1) (Garrett, 1981, pp. 313) With the standardized variables, the regression coefficients will be having the same value as that of the corresponding correlation coefficients. The regression coefficients are directional in the sense that they indicate the direction in the form of independent variable as the cause of the corresponding dependent

variable. Thus, the regression coefficients in the regression models of the standardized variables, have come to named as path (directional) coefficients, with the path (direction) being from an independent variable towards the corresponding dependent variable. Hence, the regression analysis carried out with the help of standardized variables has come to be known as path analysis. It is worth nothing that, the values of the path coefficients as regression coefficients of standardized variables, are the same in their values as those of the corresponding correlation coefficients. In magnitude, the correlation *coefficients are the same as the path coefficients but path coefficients* are directional while the correlation coefficients are not directional, though both are independent of the units of measurement of the corresponding variables.

Added advantage of path analysis over multiple linear regression analysis is that of finding the direct and indirect effects of the independent variables on the corresponding dependent variable. In general, a variable can have its effect on a dependent variable with the effect being revealed by the magnitude and the direction of the path coefficient of the independent variable. It can also have an effect on the dependent variable by the virtue of its relation with another independent variable. Thus, the effect of an independent variable on a dependent variable as revealed by the path coefficient of the independent variable is known as direct effect of the independent variable. On the other hand, the effect of an independent variable

through another independent variable is termed as indirect effect of the independent variable on the dependent variable.

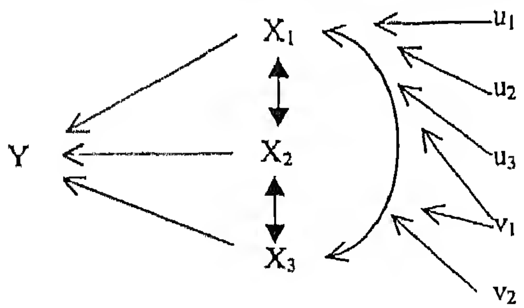
Figure – 5.2 : Direct and Indirect Paths



In the above figures P_1 is direct effect of X_1 on Y, $r_{2.1}$ P_1 is indirect effect of X_1 on Y through X_2 and P_2 is direct effect of X_2 on Y.

A variable not exerting direct effect on the dependent variable, may exert indirect effect on the dependent variable through an independent variable. Such a phenomena holds good in many situations

Figure – 5.3 : Indirect Paths through Intermediatory Variables



In the above figure X_1, X_2 and X_3 are the independent variables each having direct effect as well as indirect effect on the dependent variable Y. The variables u_1, u_2, u_3, v_1 and v_2 are also the independent variables with only indirect effect on Y through some or all of the independent variables X_1, X_2 and X_3 as indicated in the Figure – 5.3.

In such situations the variables X_1, X_2 and X_3 are called the intermediatory variables between Y and u_1, u_2, u_3, v_1 and v_2.

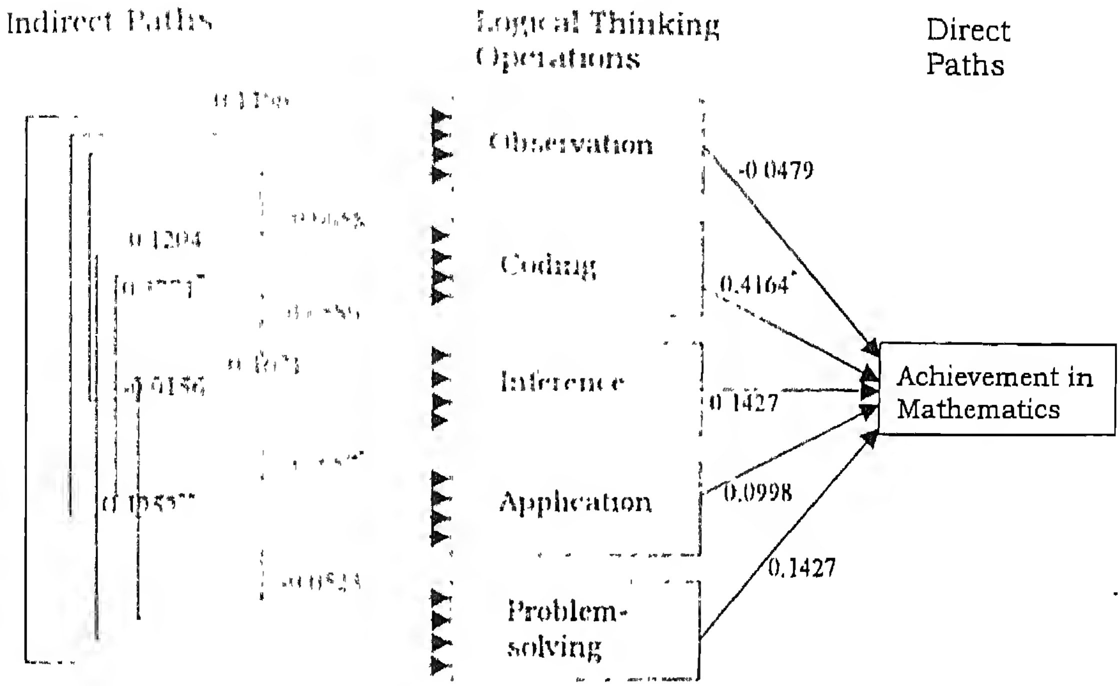
From the above narration it is evident that a variable can have only direct effect, only indirect effect and both direct and indirect effects on a dependent variable or variables.

Direct and Indirect Paths from Logical Thinking Operations to Achievement in Mathematics among SC Students

Multiple regression analysis of standardised logical thinking operations and academic achievement variables was carried out to identify direct paths (effects) from each of the logical thinking operations to the academic achievement in mathematics variable. The simple correlation of a logical thinking operation with another logical thinking operation having significant direct path with an academic achievement variable, was considered as indirect path from the logical thinking operation to the academic achievement variable through the other logical thinking operation having direct effect. The actual values of indirect paths were to be obtained as partial correlation coefficients among the logical thinking operations but it was beyond scope of the study.

The diagram of direct and indirect paths from each of the logical thinking operations to the academic achievement variable is presented in Figure – 5.4.

Figure – 5.4 : Direct and Indirect Effects of Logical Thinking Operations with Mathematics Achievement Scores (SC)



From the figure of direct and indirect paths the following observations were made :

i. The logical thinking operation, i.e., coding has direct effect on academic achievement in mathematics with direct path coefficient as 0.4164 in case of SC students. Moreover, inference (0.1427), application (0.0998) and problem–solving (0.1427) having positive effect on academic achievement in mathematics. However, observation (-0.0479) having negative effect on achievement in mathematics. However, coding also exert indirect effect in respective direction on academic achievement through application. Similarly, observation (0.1252) and inference (0.3657) having

significantly indirect effect on academic achievement in mathematics through application.

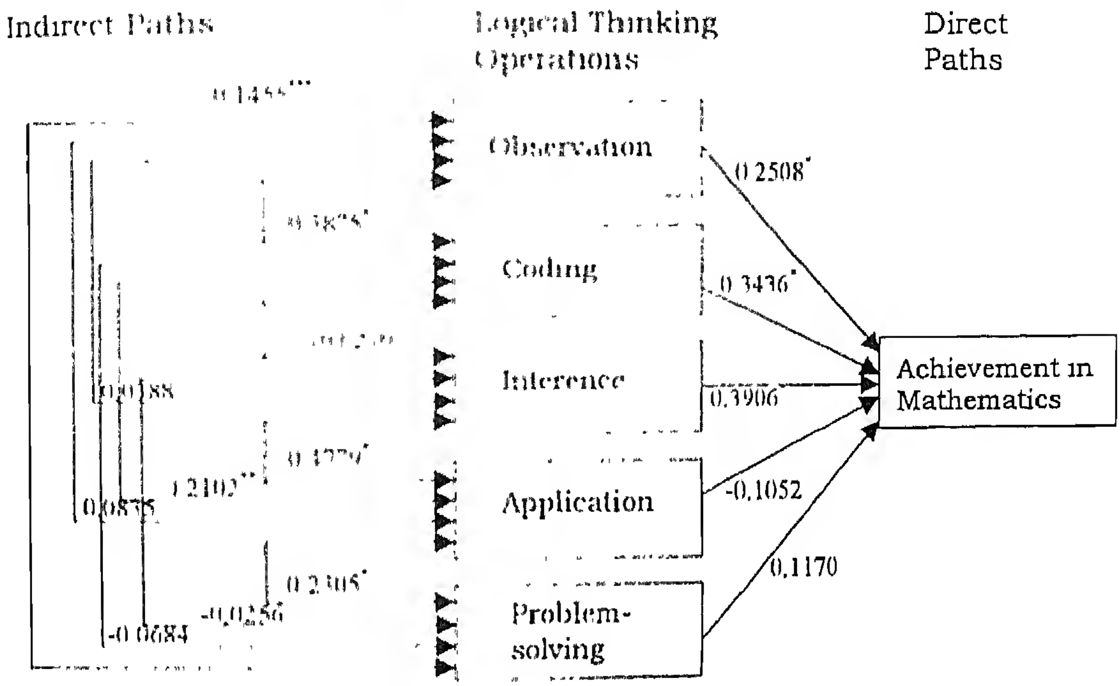
ii. Each of the variables observation, coding, inference, application and problem–solving have indirect effect on academic achievement in mathematics with the respective direct path coefficients as 0.1190, 0.0658, 0.1204, 0.0886, - 0.0156, 0.1071 and -0.0523. This shows that the logical thinking operation, i.e., coding exert positive direct effect as well as indirect effect on academic achievement in mathematics. But the operation, i.e., observation is having negative effect on academic achievement. However, all the logical thinking operations have positive indirect effect on academic achievement in mathematics among scheduled caste students

Direct and Indirect Paths from Logical Thinking Operations to Achievement in Mathematics among ST Students

Simple correlation coefficients among the logical thinking operations were considered as indirect paths from the corresponding logical thinking operation to the total academic achievement in mathematics through another logical thinking operation. The actual value of the indirect paths were to be obtained as partial correlation coefficient among the logical thinking operations but it was beyond the scope of the study.

Path analysis of logical thinking operations with the academic achievement in mathematics variable in case of ST students has revealed the following relations with regard to direct and indirect path effects as indicated in the Figure – 5.5

Figure – 5.5 : Direct and Indirect Effects of Logical Thinking Operations with Mathematics Achievement Scores (ST)



From the figure of direct and indirect paths the following observations are made :

i. The logical thinking operations, i.e., observation, coding and inference have direct significant effects on academic achievement in mathematics in case of ST students to the extent of 0.2508, 0.3436 and 0.3906 respectively. However, the application has negative direct effect (-0.1052) on academic achievement in mathematics. This shows that the ST students are lagging behind in the mastery of the logical thinking operation application. The direct effect of problem–solving on achievement in mathematics is positive but not significant in case of ST students.

ii. The logical thinking operations observation, coding, inference, application and problem–solving have indirect effects on academic achievement in mathematics. The observation of the Figure – 5.5 reveals the following :

a. The logical operation 'observation' exert significant indirect effect (0.1455 at 0.10 level) on achievement in mathematics through problem-solving (0 1455 at 0.10 level) as well as coding (0.3875 at 0.01 level).

b. The operation 'coding' exert significant indirect effect on achievement in mathematics through application (0.2102 at 0.05 level).

c. The operation 'inference' exert significant indirect effect on achievement in mathematics through application (0.4779 at 0.01 level).

d. The logical operation 'application' although it has negative direct effect on achievement in mathematics (-0.1052), however, it exerts significant indirect effect (0.2305 at 0.01 level) on achievement through problem–solving.

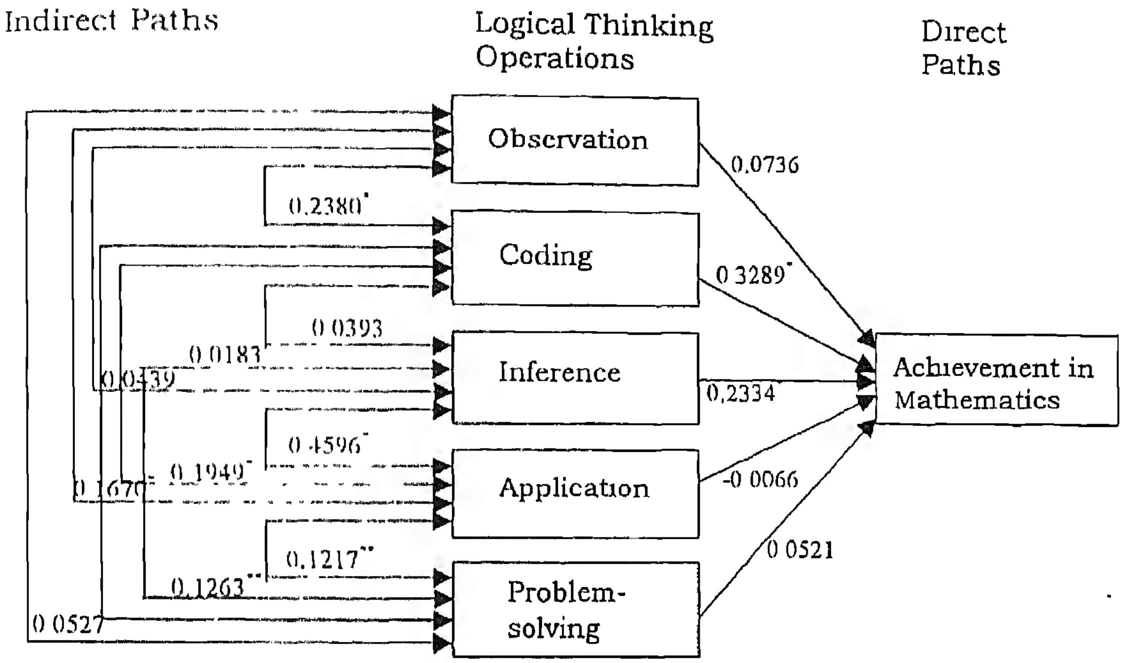
iii. The indirect effects of 'coding' through inference (-0.0230), coding through problem–solving (-0.0684), and inference through problem–solving (-0.0256) on achievement in mathematics is negative. This shows that these variables have indirect suppressing effect on achievement in mathematics.

Direct and Indirect Paths from Logical Thinking Operations to Achievement in Mathematics among General Category Students

The variable academic achievement in mathematics is having its values as the sum total of logical thinking operations, viz., observation, coding, inference, application and problem–solving. Multiple regression analysis of standardized logical thinking operation variables and standardized academic achievement in mathematics variable was carried out to identify direct path effects from each of the logical thinking variables to the academic achievement in mathematics variable. Simple correlation coefficients among the logical thinking variables were considered as indirect paths, from the corresponding logical thinking variables to the achievement in mathematics variable through another logical thinking variable. The actual values of indirect paths were to be obtained as partial correlation coefficients among the logical thinking variables but it was beyond the scope of the study.

Path analysis of logical thinking operations, viz., observation, coding, inference, application and problem–solving with the academic achievement in mathematics has revealed the following relations with regard to direct and indirect path effects as indicated in the Figure – 5.6.

Figure – 5.6 : The Direct and Indirect Effects of Logical Thinking Operations with Mathematics Achievement Scores (GM)



From the figure of direct and indirect paths the following observations are made :

i. The logical thinking operation, i.e., coding and inference have direct significant effects on academic achievement in mathematics in case of General Category students to the extent of 0.3289 and 0.2334 respectively. However, the application has negative direct effect (-0.0066) on academic achievement in mathematics. This shows that the General Category students are lagging behind in the mastery of the logical thinking operation application. The direct effects of logical thinking operations, viz., observation and problem-solving on achievement in mathematics is positive but not significant in case of General Category students

ii. The logical thinking operations observation, coding, inference, application and problem–solving have indirect effects on academic achievement in mathematics. The observation of the Figure – 5.6 reveals the following :

a. The logical thinking operation 'coding' exert significant indirect effect (0.1949 at 0.01 level) on achievement in mathematics through application and also through problem–solving (0.1263 at 0.05 level).

b. The operation 'inference' exerts significant indirect effect on achievement in mathematics through application (0.4596 at 0.01 level).

c. The operation 'application' although it has negative direct effect on achievement in mathematics (-0.0066), however, it exerts significant indirect effect (0.1217 at 0.05 level) on achievement through problem–solving.

iii. The indirect effects of 'observation' through 'coding' (0.2380), observation through 'inference' (0.0439), observation through Problem-solving(0.0527), 'coding' through inference (0.0393) and inference through problem–solving (0.1263) on achievement in mathematics is positive but not significant in case of General Category students. This implies that General Category students are lagging behind in the logical thinking operation like application and problem–solving.

It is revealed from the analysis of logical thinking operations in all the three groups that logical thinking operations like application and problem-solving have failed to influence upon the academic achievement in mathematics at the secondary school level

Hence, it is suggested that the present mathematics syllabus, textbook and teaching method are more effective in developing only the basic logical thinking operations like observation coding and inference, but not the remaining top two logical thinking operations. It has been suggested to include suitable activities in the syllabus and textbooks of mathematics so that the students of IX Standard may attain these mathematical operation during the formal course itself.

Section – 6

5.6 Principle Component Factor Analysis

When number of variables is large, it is difficult to interpret the data in terms of each and every variable taking into account the internal relations among them. One way of overcoming this difficulty is to consider linear combinations of the variables rather than the variables being considered individually. These linear combinations are to be such that they are independent of one another each forming a distinct identity by itself, such linear combinations are called 'principle components'.

The combination that accounts for maximum of the variation of the variables is known as the 'first' principle component, the combination that accounts for next maximum of the variation of the variables is known as 'second' principle component, the same holds good for the other principle components. It is common to consider those principle components which accounts for most part of the maximum variation of the variables considered together.

The procedure of obtaining principle components is through the construction of variance co-variance matrix of the variable denoted as Σ. The values of λ obtained by solving the matrix equation $|\Sigma - \lambda I| = 0$, are known as eigen values. These are denoted as $\lambda_1 \lambda_2 \lambda_3 \ldots$ and so on. In the above equation I is known as identity matrix of the same order as that of Σ, it will be having value one along the leading diagonal with

non-diagonal elements as zero. The vectors satisfying the equations $|\Sigma - \lambda_i I| V_i = 0$, are called 'principle eigen vectors' of the corresponding eigen values of Λ denoted as λ_i. It is most common to represent eigen vectors in normalized form by dividing each element of the vector by the square root of the sum of squares of the elements. There will be as many principle components as the number of variables with λ_i as the variance of the respective principle component. Objective of going for principle components is to select only those principle components called 'factors', that account for most part of the variation of the variables as revealed by the sum of the corresponding eigen values. The analysis carried out in terms of these factors is known as 'factor analysis'. In short, principle components as linear combinations of the variables, enable one to identify those principle components called factors that contribute most to the total variation of the variables With the help of these factors it is possible to carryout further analysis and identity the most important variables associated with the factors. This approach is most common and found to be very useful in studies pertaining to educational psychology. Thus, this method is incorporated in this study and various steps involved in the analysis are explained with the help of different tables that are being constructed.

The present study undertaken consists of 5 variables. The corresponding principle components with their eigen values as well as contribution of each of the principle components towards variation,

are presented in the following table along with the cumulative contribution of the principle components towards total variation of the variables.

Principle Components in Linear Combination

Table – 5.32 : Principle Components in Linear Combination – SC, ST and GM Categories

Scheduled Caste Category (SC)					
Variables	Commonality	Factor	Eigen Value	Percentage Variation	Percentage cum Variation
Observation	1.0000	1	1.9973	39.94	39.94
Coding	1.0000	2	1.0787	21.57	61.52
Inference	1.0000	3	0.8967	17.90	79.50
Application	1.0000	4	0.5737	11.50	90.90
Problem–Solving	1.0000	5	0.4535	9.10	100.00
Scheduled Tribe Category (ST)					
Variables	Commonality	Factor	Eigen Value	Percentage Variation	Percentage cum Variation
Observation	1.0000	1	1.8607	37.20	37.20
Coding	1.0000	2	1.0224	20.40	57.70
Inference	1.0000	3	0.8875	17.70	75.40
Application	1.0000	4	0.7273	14.50	90.00
Problem–Solving	1.0000	5	0.5022	10.00	100.00
General Merit Category (GM)					
Variables	Commonality	Factor	Eigen Value	Percentage Variation	Percentage cum Variation
Observation	1.0000	1	2.1684	43.41	43.40
Coding	1.0000	2	0.9966	19.90	63.30
Inference	1.0000	3	0.8907	17.80	81.10
Application	1.0000	4	0.5242	10.50	91.60
Problem–Solving	1.0000	5	0.4201	8.40	100.00

From the Table 5.32, it is evident that in case of SC category students, the first two operations like 'observation' and 'coding' are having eigen value more than 1. Hence, as suggested by Kaiser, H. F. (1958) only these two operations are worthy of being considered. It can be verified that 'observation' and 'coding' explain the variation of the variables to the extent of 61.52 per cent. Hence, further analysis is carried out with this limitation.

In case of ST category students, it can be noticed that again operations like 'observation' and 'coding' explain the variation of the variables to the extent of 57.70 per cent.

However, in case of General Category students, it is evident that for the operation 'observation' the eigen value is more than 1 and for the operation 'coding' the eigen value is 0.9966 which almost equal to 1. Hence, it can be said that the variation of the variables to the extent of 63.30 per cent. Factor matrix with their loading (elements) of the factors that correspond of the respective variables is presented below .

Matrix of Factor Loading

Table –5.33 : Matrix of Factor Loading SC, ST and GM Categories

Scheduled Caste Category (SC)		
Variables	Un-rotated	
	Factor – 1	Factor –2
Observation	-0.6470	0.5244
Coding	-0.6045	0.5969
Inference	0.6027	-0.5205
Application	0.7754	-0.3350
Problem solving	0.4988	-0.2537
Explained Variation	1.9973	1.0787
Proportion to Total	0.3995	0.2157

Scheduled Tribe Category (ST)		
Variables	Un-rotated	
	Factor – 1	Factor –2
Observation	-0.3659	0.6348
Coding	-0.7238	-0.0906
Inference	-0.6823	-0.2624
Application	-0.7775	-0.2994
Problem–solving	-0.3644	0.6728
Explained Variation	1.8607	1.0224
Proportion to Total	0.3721	0.2045

General Merit Category (GM)		
Variables	Un-rotated	
	Factor – 1	Factor –2
Observation	0.6147	0.0165
Coding	0.6647	-0.5206
Inference	0.6799	0.5361
Application	0.7631	0.3625
Problem–solving	0.5515	-0.5536
Explained Variation	2.1684	0.9966
Proportion to Total	0.4337	0.1993

In order to derive meaningful conclusions and to obtain independent variances of variables corresponding to each factor, rotation of the factor matrix is carried out. The rotated matrix of factors with their loadings are presented below :

Varimax Rotated Factor Matrix

Table – 5.34 : Varimax Rotated Factor Matrix SC, ST and GM Categories

Scheduled Caste Category (SC)		
Variables	Factor Loading	
	Factor – 1	Factor –2
Observation	0.1511	0.8190 *
Coding	0 0717	0.8465 *
Inference	0.7964 *	-0.0041
Application	0.8071 *	0.2491
Problem-solving	0.5440	0.1312
Explained Variation	1.6095	1.4665
Proportion to Total	0.3219	0.2933
Scheduled Tribe Category (ST)		
Variables	Factor Loading	
	Factor – 1	Factor –2
Observation	0.0832	0.7279 *
Coding	0.7001 *	0.2048
Inference	0.7304 *	0.0306
Application	0.8324 *	0.0345
Problem–solving	0.0667	0.7623 *
Explained Variation	1.7280	1.1550
Proportion to Total	0.3456	0.2310
General Merit Category (GM)		
Variables	Factor Loading	
	Factor – 1	Factor –2
Observation	0.4798	0 3847
Coding	0.1708	0.8269 *
Inference	0.8653 *	0.0303
Application	0.8166 *	0.2165
Problem–solving	0.0631	0.7788 *
Explained Variation	1.6790	1.4860
Proportion to Total	0.3358	0 2972

Square of each of the factor loading of a factor represents variance of the corresponding variable associated with the factor. Thus, the sum of the squares of the factor loading in all the factors of the corresponding variable is known as 'Commonality' of the variables which plays an important role in explaining the contribution of the variable in representation with factors as axes. This is represented in the Table – 5.35.

Percentage of Variance Accounted by Each Factor

Table – 5.35 : Variablewise Common Factor Variable Commonalities and Percentage of Variance Accounted for by Each Factor

Scheduled Caste Category (SC)			
Variables	Factor Variance		Commonality
	Factor - 1	Factor - 2	
Observation	0.02283	0.67076 *	0.69359
Coding	0.00514	0.71656 *	0.72170
Inference	0.63425 *	0.00002	0.63427
Application	0.65141 *	0.06205	0.71346
Problem-solving	0.29594	0.01721	0.31315
Total Variance	1.60957	1.4666	3.07617
Percentage of Variance	52.32383	47.67617	100.0000
Scheduled Tribe Category (ST)			
Variables	Factor Variance		Commonality
	Factor – 1	Factor - 2	
Observation	0.00692	0.52983 *	0.53675
Coding	0.49014 *	0.04194	0.53208
Inference	0.53348 *	0.00093	0.53441
Application	0.69289 *	0.00119	0.69408
Problem–solving	0.00445	0.58110 *	0.58555
Total Variance	1.727879	1.15499	2.88287
Percentage of Variance	59.9361	40.06389	100.0000
General Merit Category (GM)			
Variables	Factor Variance		Commonality
	Factor - 1	Factor - 2	
Observation	0.23021	0.14799	0.37818
Coding	0.02917	0.68376 *	0.71293
Inference	0.74874 *	0.00092	0.74966
Application	0.66684 *	0.04687	0.71371
Problem–solving	0.00398	0.60653 *	0.61051
Total Variance	1.67894	1.48608	3.16499
Percentage of Variance	53.04725	46.95370	100.0000

It is revealed from the above table that in case of SC, ST and General Category students the total variation indicated against each factor in the Table – 5.35 indicates variance of the factor obtained through rotation of the factors. It is worth noting that the sum of the total variation of the two factors is the same as the sum of the first two eigen values of the principle components. Similarly, the sum of the commonalities of these variables is also equal to the sum of first two eigen values. This shows that no information is lost by rotating the factors. The rotated factors provide clear cut picture of the relations among the factors and the variables as well as variation due to each of the variable contributed to each of the factor. It is most common to express total variation of the factors as percentage of the sum of the total variation of the factors. The sum is indicated in the last row of the Table – 5.35.

1. Scheduled Caste Category

It is evident from the Table – 5.34 that out of five logical thinking operations, two logical operations, viz., 'inference' and 'application' on Factor –1 are having more factor loading than any other operations. All the logical thinking operations in the first factor were positively associated among themselves. The key logical operations in case of SC students with respect to academic achievement in mathematics variable were 'observation' with factor loading 0.1511, 'coding' with factor loading 0.0717, 'inference' with factor loading 0.7964, 'application' with factor loading 0.8071 and

'problem–solving' with factor loading 0.5440. In logical thinking operations, the factor loading varied from 0.0717 to 0.8071.

It is evident form the Table – 5.34 that out of five logical thinking operations, two logical thinking operations, viz., 'observation' and 'coding' on Factor – 2 are having more factor loading than any other operations. All the logical thinking operations except 'inference' in the second factor were positively associated among themselves. The key logical operations in case of SC students with respect to academic achievement in mathematics variable were 'observation' with factor loading 0.8190, 'coding' with factor loading 0.8465, 'inference' with factor loading -0.0041, 'application' with factor loading 0.2491 and 'problem–solving' with factor loading 0.1312. In logical thinking operations, the factor loading varied from -0.0041 to 0.8465.

2. Scheduled Tribe Category

It is evident form the Table – 5.34 that out of five logical thinking operations, three logical thinking operations, viz., 'coding', 'inference' and 'application' on Factor–1 are having more factor loading than any other operations. All the logical thinking operations in the first factor were positively associated among themselves. The key logical operations with respect to academic achievement in mathematics variable in case of ST category students were 'observation' with factor loading 0.0832, 'coding' with factor loading 0.7001, 'inference' with factor loading 0.7304, 'application' with factor loading 0.8324 and 'problem–solving' with factor loading 0.0667 In

logical thinking operations, the factor loading varied from 0.0667 to 0.8324.

It is evident form the Table – 5.34 that out of five logical thinking operations, two logical thinking operations, viz., 'observation' and 'problem-solving' on Factor –2 with more factor loading than any other operations. All the logical thinking operations except 'inference' in the second factor were positively associated among themselves. The key logical thinking operations with respect to academic achievement in mathematics variable in case of ST category students were 'observation' with factor loading 0.7279, 'coding' with factor loading 0.2048, 'inference' with factor loading 0.0306, 'application' with factor loading 0.0345 and 'problem–solving' with factor loading 0 7623. In logical thinking operations, the factor loading varied from 0.0345 to 0.7623.

3. General Category

It is evident form the Table – 5.34 that out of five logical thinking operations, two logical thinking operations, viz., 'inference' and 'application' are having more factor loading than any other operations on Factor–1. All the logical thinking operations in the first factor were positively associated among themselves. The key logical operations in case of General Category students with respect to academic achievement in mathematics variable were 'observation' with factor loading 0.4798, 'coding' with factor loading 0.1708, 'inference' with factor loading 0.8653, 'application' with factor loading 0.8166

and 'problem solving' with factor loading 0.0631. In logical thinking operations, the factor loading varied from 0.0631 to 0 8653.

It is evident form the Table – 5.34 that out of five logical thinking operations, two logical thinking operations, viz., 'coding and 'problem–solving' on Factor - 2 are having more factor loading than any other operations. All the logical thinking operations in the second factor were positively associated among themselves The key logical operations with respect to academic achievement in mathematics variable in General Category students were 'observation' with factor loading 0.3847, 'coding' with factor loading 0.8269, 'inference' with factor loading 0 0303, 'application' with factor loading 0.2165 and 'problem–solving' with factor loading 0.7788. In logical thinking operations, the factor loading varied from 0.0303 to 0.8269.

The eigen value for each factor was calculated separately. In case of SC students, the value for Factor – 1 was 1.60957 and for Factor – 2 was 1.4666. In case of ST students, the value for Factor – 1 was 1.727879 and for Factor–2 was 1.15499. In case of General Category students the value for Factor – 1 was 1.67894 and for Factor – 2 was 1.48608 respectively expressed in percentage. These eigen values indicate the contribution of each factor towards total variation.

Major Finding

The analysis using principle component factor analysis revealed the following findings :

i. The logical thinking operations like 'inference' and 'application' in case of SC, ST and General Category students have been clustered under a single group (factor) with high factor loading. This implies that the logical thinking operations like 'inference' and 'application' in all the three category students play a major role in the over all success in the academic achievement of IX Standard students in mathematics.

ii. Logical thinking operations like 'observation' and 'coding' in case of SC students; 'problem–solving' and 'observation' in case of ST students; and 'coding' and 'problem–solving' in General Category students have been clustered under a single group with high factor loading. This implies that in SC students 'observation' and 'coding' operations plays a major role in the achievement in mathematics. In case of ST students, the success in mathematics depends upon operations 'problem–solving' and 'observation'. In General Category students the logical operations 'coding' and 'problem –solving' to a great extent determine the academic success of IX Standard students in mathematics.

iii. It is rather interesting to note in the context of present study that the logical thinking operations like 'inference' and 'application' have been clustered under a single group. Hence, the first factor is

named as '*Inference - Application*'. The Table – 5.35 shows that 52.32383%, 59.9361% and 53.04725% of the variations in case of SC, ST and General Category students can be expressed in terms of this factor named as '*Inference – Application*'.

CHAPTER – VI

DISCUSSION AND CONCLUSION

6.1 Comparative Analysis

With reference to the comparison of logical thinking operations in mathematics among SC, ST and General Category students, it has been found that -

1. SC and ST students differ significantly in their logical thinking operation, i.e., Observation.

2. SC and General Category students do not differ significantly in their logical thinking operation, i.e., Observation.

3. ST and General Category students do not differ significantly in their logical thinking operation, i.e., Observation.

4. SC and ST students do not differ significantly in their logical thinking operation, i.e., Coding.

5. SC and General Category students do not differ significantly in their logical thinking operation, i.e., Coding.

6. ST and General Category students do not differ significantly in their logical thinking operation, i.e., Coding.

7. SC and ST students do not differ significantly in their logical thinking operation, i.e., Inference.

8. SC and General Category students differ significantly in their logical thinking operation, i.e., Inference.

9. ST and General Category students do not differ significantly in their logical thinking operation, i.e., Inference

10. SC and ST students differ significantly in their logical thinking operation, i.e., Application.

11 SC and General Category students differ significantly in their logical thinking operation, i.e., Application.

12. SC and General Category students do not differ significantly in their logical thinking operation, i.e., Application.

13 SC and ST students do not differ significantly in their logical thinking operation, i.e., Problem-solving.

14. SC and General Category students do not differ significantly in their logical thinking operation, i e., Problem-solving.

15. ST and General Category students do not differ significantly in their logical thinking operation, i.e., Problem-solving.

It is revealed from the findings that SC and ST category students differ in their 'observation' ability; SC and General category students differ in their 'inference' ability; SC and ST students, SC and

General Category students differ in their 'application' ability. When compared to students from General Category and ST category, SC students are lagging behind in the abilities like 'observation', 'inference' and 'application'. Thus, intervention programme in these abilities is essential to SC category students.

Based on the above stated findings, the following conclusions may be drawn :

i. Socio economic status of SC and ST students has a beneficial effect on the attainment of logical thinking operation 'Observation'.

ii. There is relationship between advantaged and disadvantaged background of the students and their ability 'Inference'.

iii. Caste has a beneficial effect on the attainment of the logical thinking operation 'Application'.

6.2 Simple Correlations

With reference to the relationship between logical thinking operations and academic achievement in mathematics, it has been found that –

i. There is a positive and significant relationship between logical thinking operations, viz., coding, inference, application, problem–solving and academic achievement in mathematics among SC category students. However, the relationship

between observation and academic achievement in mathematics is not significant.

ii. There is a positive and significant relationship between logical thinking operations, viz., coding, inference, application, problem–solving and academic achievement in mathematics among ST category students. However, the relationship between observation and academic achievement in mathematics is not significant.

iii. The logical thinking operations like observation, coding, inference, application and problem–solving are positively and significantly related with academic achievement of General Category students in mathematics.

In case of Scheduled Caste and Scheduled Tribe students the correlation between logical thinking operation, i.e., observation and achievement in mathematics is not significant. This implies that the SC and ST students are lacking behind in the attainment of the ability 'Observation'.

Based on the above stated findings, the following conclusions may be drawn :

i. The logical thinking operation 'observation' has no significant relationship with academic achievement in case of SC and ST category students, whereas it is having positive and significant relationship with academic achievement in case of General Category students.

ii. The logical thinking operations like 'coding', 'inference', 'application' and 'problem-solving' are having positive and significant relationship with academic achievement in SC, ST and General Category students.

6.3 Interaction Effect

With reference to the interaction effect of Sex, Caste and Attitude on logical thinking operations in mathematics, it has been found that :

1. Boys and girls do not differ significantly in respect of their logical thinking operation 'Observation'.

2. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation 'Observation'.

3. Students with favourable and unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Observation'.

4. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation 'Observation'.

5. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Observation'.

6. Advantaged/Disadvantaged students with favourable/ unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Observation'.

7. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Observation.

8. Boys and girls do not differ significantly in respect of their logical thinking operation 'Coding'.

9. Advantaged/disadvantaged students do not differ significantly in respect of their logical thinking operation 'Coding'.

10. Students with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation 'Coding'.

    Students with favourable attitude towards mathematics in greater number attain logical thinking operation 'coding' than those with unfavourable attitude towards mathematics.

11. Boys/Girls with advantaged/disadvantaged background differ significantly in respect of their logical thinking operation 'Coding'.

    Girls with advantaged background are better in their logical thinking operation 'coding' than the boys with advantaged background.

Girls with advantaged background are better in their logical thinking operation 'coding' than the girls with disadvantaged background.

12. Boys/Girls with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation 'Coding'.

Boys with favourable attitude towards mathematics are better in their 'coding' ability than the boys with unfavourable attitude.

Boys with favourable attitude towards mathematics are better in their 'coding' ability than the girls with unfavourable attitude.

Boys with favourable attitude towards mathematics are better in their 'coding' ability than the girls with unfavourable attitude.

Girls with favourable attitude towards mathematics are better in their 'coding' ability than the boys with unfavourable attitude.

Girls with favourable attitude towards mathematics are better in their 'coding' ability than the boys with unfavourable attitude.

13. Boys/Girls with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation 'Coding'.

Students from advantaged background with unfavourable attitude are better in 'coding' ability than the students from disadvantaged background with favourable attitude.

Students from advantaged background with unfavourable attitude is better in 'coding' ability than the students from disadvantaged background with favourable attitude.

Students from advantaged background with favourable attitude are better in 'coding' ability than the students from disadvantaged background with favourable attitude.

Students from advantaged background with unfavourable attitude are better in 'coding' ability than students from disadvantaged background with unfavourable attitude.

Students from disadvantaged background with favourable attitude are better in 'coding' ability than students from disadvantaged background with unfavourable attitude

14. Boys/Girls from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation 'Coding'.

Boys from disadvantaged background with favourable attitude are better in 'coding' ability than the boys from advantaged background with favourable attitude towards mathematics.

Boys from disadvantaged background with favourable attitude are better in 'coding' ability than the boys from advantaged background with unfavourable attitude

Boys from disadvantaged background with favourable attitude are better in 'coding' than the boys from disadvantaged background with unfavourable attitude.

Boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from advantaged background with favourable attitude.

Boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from advantaged background with unfavourable attitude.

Boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from disadvantaged background with favourable attitude.

Boys from disadvantaged background with favourable attitude are better in 'coding' ability than the girls from disadvantaged background with unfavourable attitude.

Boys from disadvantaged background with unfavourable attitude are lacking in 'coding' ability when compared to girls from advantaged background with favourable attitude.

Girls from advantaged background with unfavourable attitude are better in 'coding' ability than the boys from disadvantaged background with unfavourable attitude.

15. Boys and Girls do not differ significantly in respect of their logical thinking operation 'Inference'.

16. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation 'Inference'.

17. Students with favourable and unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Inference'.

18. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation 'Inference'.

19. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Inference'.

20. Advantaged/disadvantaged students with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Inference'.

21. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Inference'.

22. Boys and Girls do not differ significantly in respect of their logical thinking operation 'Application'.

23. Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation 'Application'.

24. Student with favourable and unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation 'Application'.

Students with favourable attitude towards mathematics are better in the logical thinking operation 'application' than the students with unfavourable attitude towards mathematics.

25. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation 'Application'.

26. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Application'.

27. Advantaged/disadvantaged students with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Application'.

28. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics differ significantly in respect of their logical thinking operation 'Application'

Boys from disadvantaged background with favourable attitude are better in their logical

thinking operation 'application' than the boys from advantaged background with favourable attitude.

Boys from disadvantaged background with favourable attitude are better in their logical thinking operation 'application' than the boys from advantaged background with unfavourable attitude.

Boys from disadvantaged background with favourable attitude are better in their logical thinking operation 'application' than the girls from advantaged background with unfavourable attitude.

Boys from disadvantaged background with favourable attitude are better in their logical thinking operation 'application' than the girls from disadvantaged background with favourable attitude

Boys from disadvantaged background with favourable attitude are better in their logical thinking operation 'application' than the girls from disadvantaged background with favourable attitude.

Girls from advantaged background with favourable attitude are better in their logical thinking operation 'application' than the boys from disadvantaged background with unfavourable attitude.

Girls from disadvantaged background with favourable attitude are better in their logical thinking operation 'application' than the boys from

disadvantaged background with unfavourable attitude.

29. Boys and Girls do not differ significantly in respect of their logical thinking operation 'Problem-solving'.

30 Advantaged and disadvantaged students do not differ significantly in respect of their logical thinking operation 'Problem-solving'.

31. Students with favourable and unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Problem-solving'.

32. Boys/Girls with advantaged/disadvantaged background do not differ significantly in respect of their logical thinking operation 'Problem-solving'.

33. Boys/Girls with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Problem-solving'.

34 Advantaged/Disadvantaged students with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Problem-solving'

35. Boys/Girls coming from advantaged/disadvantaged background with favourable/unfavourable attitude towards mathematics do not differ significantly in respect of their logical thinking operation 'Problem-solving'.

Based on the above stated findings, the following conclusions may be drawn .

i Favourable and unfavourable attitude towards mathematics influence upon logical thinking operations 'coding' and 'application'.

ii. Sex and caste, sex and attitude; and caste and attitude taken two factors at a time jointly influence upon logical thinking operations 'Coding'.

iii. Further, the interaction among all three selected factors – sex, caste and attitude – influence upon logical thinking operations 'Coding' and 'Application'.

6.4 Multiple Regression Analysis

With reference to the prediction of academic achievement in mathematics with criterion variables like logical thinking operation, it has been found that –

i. In case of SC category students, 'coding' seems to be the best predictor of all the predictor variables, the next best predictors of total academic achievement in mathematics in the order of priority are 'inference', 'application' and 'problem-solving', whereas 'observation' has suppressing effect on the academic achievement in mathematics among SC category students.

ii. In case of ST category students, 'inference' seems to be the best predictor of all the predictor variables ;

the next best predictors of the total academic achievement in mathematics in the order of priority are 'coding', 'observation' and 'problem–solving', whereas 'application' has suppressing effect on the academic achievement in mathematics among ST category students.

iii. In case of General Category students, coding seems to be the best predictor of all the predictor variables; the next best predictors of total academic achievement in mathematics in the order of priority are 'inference', 'observation' and 'problem–solving', whereas 'application' has suppressing effect on the academic achievement in mathematics among General Category students.

Based on the above stated findings, the following conclusions may be drawn :

i. The 'Coding' seems to be the best predictor of academic achievement in mathematics. The next best predictors in the order of priority, are 'Inference', 'Application' and 'Problem-solving' in case of SC category students.

ii. 'Inference', 'Observation' and 'Problem-solving' are the best predictors in case of General Category students.

iii. In case of ST category students the 'Inference' seems to be the best predictor of all the predictor variables. The next best predictors in the order of priority are 'Coding', 'Observation' and 'Problem-solving'.

iv. The operation 'Observation' in SC category students and 'Application' in ST and General Category students will have suppressing effect on the academic achievement in mathematics.

6.5 Path Analysis

With reference to the direct and indirect effects of independent variables (logical thinking operations) on dependent variable (academic achievement in mathematics), it has been found that –

i. The logical thinking operation, i.e., 'coding' has direct effect on academic achievement in mathematics in case of SC students. Moreover, 'inference', 'application' and 'problem–solving' having positive effect on academic achievement in mathematics. However, 'observation' having negative effect on achievement in mathematics. However, 'coding' also exert indirect effect in respective direction on academic achievement through 'application'. Similarly, 'observation' and 'inference' having significantly indirect effect on academic achievement in mathematics through 'application'.

ii. Each of the variables 'observation', 'coding', 'inference', 'application' and 'problem–solving' have indirect effect on academic achievement in mathematics. This shows that the logical thinking operation, i.e., 'coding' exert positive direct effect as well as indirect effect on academic achievement in mathematics. But the operation, i.e., 'observation'

is having negative effect on academic achievement. However, all the logical thinking operations have positive indirect effect on academic achievement in mathematics among scheduled caste students.

iii. The logical thinking operations, i.e., 'observation', 'coding' and 'inference' have direct significant effects on academic achievement in mathematics in case of ST students. However, the 'application' has negative direct effect on academic achievement in mathematics. This shows that the ST students are lagging behind in the mastery of the logical thinking operation 'application'. The direct effect of 'problem–solving' on achievement in mathematics is positive but not significant in case of ST students.

iv. The logical thinking operations 'observation', 'coding', 'inference', 'application' and 'problem–solving' have indirect effects on academic achievement in mathematics.

   a. The logical operation 'observation' exert significant indirect effect on achievement in mathematics through 'problem–solving' as well as 'coding'

   b. The operation 'coding' exert significant indirect effect on achievement in mathematics through 'application'.

   c. The operation 'inference' exert significant indirect effect on achievement in mathematics through 'application'.

d. The logical operation 'application' although it has negative direct effect on achievement in mathematics, however, it exerts significant indirect effect on achievement through 'problem–solving'.

v. The indirect effects of 'coding' through 'inference', 'coding' through 'problem–solving', and 'inference' through 'problem–solving' on achievement in mathematics is negative. This shows that these variables have indirect suppressing effect on achievement in mathematics.

vi. The logical thinking operation, i e., 'coding' and 'inference' have direct significant effects on academic achievement in mathematics in case of General Category students. However, the 'application' has negative direct effect on academic achievement in mathematics. This shows that the General Category students are lagging behind in the mastery of the logical thinking operation 'application'. The direct effects of logical thinking operations, viz., 'observation' and 'problem–solving' on achievement in mathematics is positive but not significant in case of General Category students.

vii. The logical thinking operations 'observation', 'coding', 'inference', 'application' and 'problem–solving' have indirect effects on academic achievement in mathematics.

a. The logical thinking operation 'coding' exert significant indirect effect on achievement in

mathematics through application and also through 'problem–solving'.

b. The operation 'inference' exerts significant indirect effect on achievement in mathematics through 'application'.

c. The operation 'application' although it has negative direct effect on achievement in mathematics, however, it exerts significant indirect effect on achievement through 'problem–solving'.

viii. The indirect effects of 'observation' through 'coding', observation through 'inference', 'observation' through 'Problem-solving', 'coding' through 'inference' and 'inference' through 'problem–solving' on achievement in mathematics is positive but not significant in case of General Category students. This implies that General Category students are lagging behind in the logical thinking operation like 'application' and 'problem–solving'.

It is revealed from the analysis of logical thinking operations in all the three groups that logical thinking operations like 'application' and 'problem–solving' have failed to influence upon the academic achievement in mathematics at the secondary school level.

Hence, it is suggested that the present mathematics syllabus, textbook and teaching method are more effective in developing only the basic logical thinking operations like 'observation', 'coding' and 'inference', but not the remaining top two logical thinking operations.

It has been suggested to include suitable activities in the syllabus and textbooks of mathematics so that the students of IX Standard may attain these mathematical operation during the formal course itself.

Based on the above stated findings, the following conclusions may be drawn :

i. In case of SC students, the logical thinking operation 'Coding has direct positive significant effect on the academic achievement in mathematics. Further, operations like 'Observation', 'Coding' and 'Inference' have indirect significant effects on achievement in mathematics.

ii. In case of ST students, the logical thinking operations like 'Observation', 'Coding' and 'Inference' have direct positive significant effects on the academic achievement in mathematics. Further, 'Observation', 'Coding', 'Inference' and 'Application' have indirect significant effects on achievement in mathematics.

iii. In case of General Category students, the logical thinking operations like 'Coding' and 'Inference' have direct positive significant effect on the academic achievement in mathematics. Further, operations like 'Observation', 'Coding', 'Inference' and 'Application' have indirect significant effects on achievement in mathematics.

6.6 Principle Component Factor Analysis

With reference to the principle components in logical thinking operations which accounts for most part of the variation in achievement in mathematics, it has been found that –

i. The logical thinking operations like 'inference' and 'application' in case of SC, ST and General Category students have been clustered under a single group (factor) with high factor loading. This implies that the logical thinking operations like 'inference' and 'application' in all the three category students play a major role in the over all success in the academic achievement of IX Standard students in mathematics.

ii. Logical thinking operations like 'observation' and 'coding' in case of SC students; 'problem–solving' and 'observation' in case of ST students; and 'coding' and 'problem–solving' in General Category students have been clustered under a single group with high factor loading. This implies that in SC students 'observation' and 'coding' operations plays a major role in the achievement in mathematics. In case of ST students, the success in mathematics depends upon operations 'problem–solving' and 'observation'. In General Category students the logical operations 'coding' and 'problem –solving' to a great extent determine the academic success of IX Standard students in mathematics.

iii. It is rather interesting to note in the context of present study that the logical thinking operations like 'inference' and 'application' have been clustered

under a single group. Hence, the factor is named as '*Inference – Application*'.

Based on the above stated findings, the following conclusions may be drawn :

i. The operation 'Inference' and 'Application' have been clustered under a single group (factor) with high factor loading. This implies that these two operations in SC, ST and General Category students play a major role in the over all success of IX Standard students in mathematics. Also the operations 'Observation' and 'Coding' in case of SC students; 'Problem-solving' in General Category students have been clustered under a single group with high factor loading.

ii. This shows that in case of SC category students the operations 'Observation' and 'Coding' plays a major role in the achievement in mathematics. However, in case of ST category students, the success in mathematics depends upon operations 'Problem-solving' and 'Observation'. Also in General Category students the operations 'Coding' and 'Problem-solving' to a greater extent determine the academic success of IX Standard students in mathematics.

6.7 Educational Implications

The present study throws light on the problem related to the teaching of mathematics in our schools. Even though mathematics has prominent place in the curriculum, the study shows that, there

are some drawbacks in the teaching and learning of mathematics. If general mathematical thinking skills exist they must facilitate transfer of strategic and procedural knowledge from one context to another. Since the present study stem from the cognitive theory, it can provide a general framework for analysing mathematics learning and learning difficulties. Some of the implications in the light of the research findings are given below.

i Since there is no difference in the thinking operations between boys and girls, between students of Aided and Government schools, provision of facilities and adoption of new models of teaching will stimulate and foster the thinking skills irrespective of gender and type of schools.

ii. Since the scheduled caste student lagged behind in the level of thinking operations in mathematics than the other students, the teacher should take some remedial measures to motivate the backward students, and provide suitable activities, and instructions to help them to acquire the thinking operations The motivational intensity for learning and achievement of scheduled caste students should be given a boost.

iii. Since the present study stem from the cognitive theory, it can provide a general framework for analysing learning difficulties in mathematics of disadvantaged children.

iv. Suppose, if the disadvantaged children are lagging behind in the attainment of sequence of logical

thinking operations in mathematics, the teacher can take some remedial measures to motivate the backward students, to provide suitable activities, and to organize instructions to help them to acquire the thinking operations.

v Suppose, if the sequence of logical thinking operation is in decreasing order from 'Observation' to 'Problem solving', care must be taken to conduct suitable activities with 'Problem–solving' situations where in the teacher can help to develop the different thinking operations in mathematics.

vi. Suppose, achievement in mathematics and sequence of logical thinking operations are positively correlated, teachers can provide conducive atmosphere to learn mathematics and to create interest among students.

vii. There is a need for reappraising the existing school curriculum to incorporate a wide range of thinking processes and skills which are ignored but are essential to facilitate learning to think and learn.

viii. The study has also implications on the syllabus and textbook construction to provide sufficient exercises to enable the disadvantaged students to develop their logical thinking operations.

6.8 Suggestions for Further Research

While conducting the present study, a need for a few specific research studies relating to the field was felt. The suggestion for such studies are enumerated below :

i. Similar studies may be conducted with a large sample and probability sampling technique could be used to increase the validity of the experiment.

ii. Similar studies may be conducted for higher order Thinking skills.

iii. Similar studies may be conducted for a long period of time under carefully controlled conditions.

iv. Similar studies may be conducted in other school subjects like English and Hindi.

v. Similar studies may be conducted for other classes, i.e., from the first standard to the tenth standard.

vi. Curriculum could be involved for nurturing Thinking skills of the pupils of High Schools.

vii Research can be carried out to find out the effect of Instructional Material designed on specific Thinking skills.

viii. The studies can focus on evolving on curriculum which stress the method of teaching Thinking Skills at the B. Ed. training level.

ix. Separate studies can be undertaken to evaluate the development of thinking attained through the implementation of methods of teaching thinking skills in Primary to High School Level.

x. Special tool can be constructed to measure the level of pupils on Thinking Skills on different subjects.

xi. More research needs to be conducted to generate evaluation techniques in Teaching for Thinking by preparing standardized tests.

xii. Research can be carried out to foster the thinking operations by developing self-instructional material in thinking operations in mathematics for the students of different classes.

xiii. Comparative studies can be undertaken on thinking operations in mathematics of the pupils belonging to different age levels.

xiv. Experimental studies can be conducted using different teaching methods for the teaching of mathematics and find their impact in the development of thinking operations in mathematics in different classes and different levels.

xv. Studies can be conducted on the different factors namely, intelligence, anxiety, interest, etc., affecting thinking operations in mathematics of the students in different classes.

xvi. Standardisation of tools on thinking operations in mathematics and other subjects for students of different classes can be developed to test the thinking operations in mathematics.

xvii. Similar studies can be done with other thinking operations in mathematics.

xviii. Study can be extended to compare the thinking operations of scheduled caste students of rural and urban area.

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APPENDIX - I

A TEST ON LOGICAL THINKING OPERATIONS IN MATHEMATICS

Time . 1 hour　　　　　　　　　　　　　　　　　　　　　　Std. . IX

ಸೂಚನೆಗಳು :

1 ಎಲ್ಲಾ ಪ್ರಶ್ನೆಗಳಿಗೆ ಕೊಟ್ಟಿರುವ ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿ ಉತ್ತರಿಸಿರಿ.

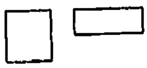
2 ಯಾವುದೇ ಪ್ರಶ್ನೆಗೆ ಉತ್ತರವನ್ನು ತಿದ್ದುಪಡಿ ಮಾಡಬೇಡಿರಿ

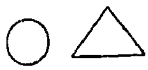
3 ಪ್ರತಿಯೊಂದು ಪ್ರಶ್ನೆಯನ್ನು ಗಮನವಿಟ್ಟು ಓದಿರಿ ಹಾಗೂ ಅದಕ್ಕೆ ಕೊಟ್ಟಿರುವ ನಾಲ್ಕು ಬೇರೆ ಬೇರೆ ಉತ್ತರಗಳಲ್ಲಿ ಸರಿಯಾದುದನ್ನು ಆಯ್ಕೆ ಮಾಡಿ ಅದರ ಇಂಗ್ಲೀಷ್ ಅಕ್ಷರವನ್ನು ಉದಾ : (a) ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿರುವ ಆ ಪ್ರಶ್ನೆಯ ಮುಂದೆ ಬರೆಯಬೇಕು.

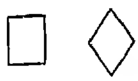
4. ಯಾವುದೇ ಉತ್ತರವನ್ನು ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆಯಲ್ಲಿ ಬರೆಯದೇ ಕೊಟ್ಟ ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿ ಮಾತ್ರ ಬರೆಯಬೇಕು.

ಉದಾಹರಣೆ 1: ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಸ್ವರೂಪತೆಯನ್ನು ಹೊಂದಿರುವ ರೇಖಾಗಣಿತ ಚಿತ್ರಗಳ ಜೋಡಿಯನ್ನು ಗುರುತಿಸಿರಿ :

a 

b. 

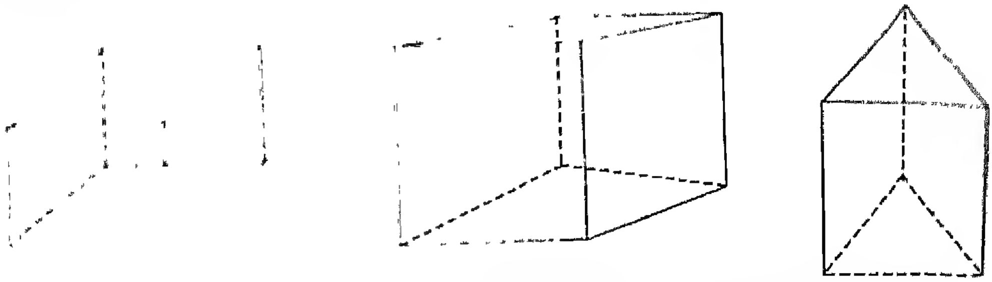
c. 

d. 

ಈ ಪ್ರಶ್ನೆಗೆ ಸರಿಯಾದ ಉತ್ತರ  ಆಗಿದೆ. ಇವುಗಳನ್ನು 'a' ಕ್ರಮ ಸಂಖ್ಯೆಯಲ್ಲಿ ಕಾಣಬಹುದು. ಆದ್ದರಿಂದ ನಿಮ್ಮ ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿ ಪ್ರಶ್ನೆ 1 ರ ಮುಂದೆ 'a' ಕ್ರಮ ಸಂಖ್ಯೆಯನ್ನು ಈ ಕೆಳಗೆ ಕೊಟ್ಟಿರುವಂತೆ ಬರೆಯಿರಿ.

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರಗಳು
1	a
2	
3	
4	

1 ಈ ಕೆಳಗಿನ ಆಕೃತಿಗಳನ್ನು ಅವಲೋಕಿಸಿ. ಅವುಗಳಲ್ಲಿರುವ ಸಾಮಾನ್ಯ ಗುಣ ಲಕ್ಷಣಗಳನ್ನು ಗುರುತಿಸಿ.



a [illegible] b [illegible] ರಚನೆ c ನಿರ್ದಿಷ್ಟ ರಚನೆ d. ಸಮರೂಪ ರಚನೆ

2 ಒಂದು ವೇಳೆ Δ ABC ~ PQR ಎಂದಾದರೆ, ಆ ತ್ರಿಭುಜಗಳನ್ನು ಈ ರೀತಿಯಾಗಿ ಕರೆಯುವರು.

a. ಸಮರೂಪ ತ್ರಿಭುಜಗಳು b ಸರ್ವಸಮ ತ್ರಿಭುಜಗಳು
c ಸಮಬಾಹು ತ್ರಿಭುಜಗಳು d ಸಮಾನ ತ್ರಿಭುಜಗಳು

3 (a, b) ಮತ್ತು (c, d) ಎರಡು ಅಣಿತ ಯುಗ್ಮಗಳು, ಒಂದು ವೇಳೆ (a, b) = (c, d) ಎಂದಾದರೆ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಯಾವುದು ಸರಿ ?

a $a = c$ ಮತ್ತು $b \neq d$ b. $a \neq c$ ಮತ್ತು $b = d$
c $a = c$ ಮತ್ತು $b = d$ d $a \neq c$ ಮತ್ತು $b \neq d$

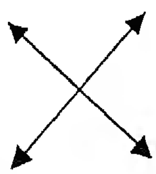
4 $(2\ \ 3)^2$ ನ್ನು ವಿಸ್ತರಿಸಿದಾಗ ಯಾವ ಪದ ಚರಾಕ್ಷರ (ಬೀಜಾಕ್ಷರ) ದಿಂದ ಹೊರತಾಗಿದೆ.

a 4 b -12 c. 9 d -9

5. ಈ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ತ್ರಿ ಪದೋಕ್ತಿಯನ್ನು ಗುರುತಿಸಿರಿ.

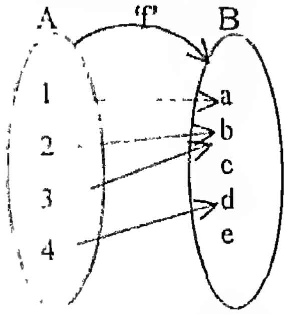
a. $x^3 + 2y^2y$ b. $m^2 + 2m + 1$ c. $3x^2y^2z^2$ d. $(x + y)^3$

6 ಈ ಕೆಳಗಿನ ಚಿತ್ರದಲ್ಲಿಯ ಗೆರೆಗಳು



a. ಲಂಬವಾಗಿವೆ b. ಸಮಾಂತರವಾಗಿವೆ
c. ಸಂಧಿಸಿವೆ (ಐಕ್ಯವಾಗಿವೆ) d. ಛೇದಿಸಿವೆ

7. ಈ ಕೆಳಗಿನ ಚಿತ್ರವು ಯಾವ ಉತ್ಪನ್ನವನ್ನು ಸೂಚಿಸುತ್ತದೆ ?



a. ಒಂದು ಒಂದು ಉತ್ಪನ್ನ
b. ಮೇಲಣ ಉತ್ಪನ್ನ
c ಉತ್ಪನ್ನವಲ್ಲ
d ಎರಡು ಒಂದು ಉತ್ಪನ್ನ

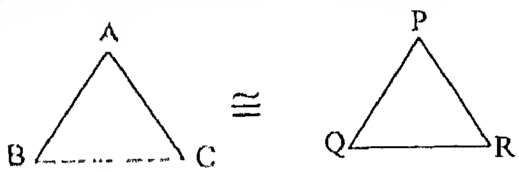
8. ಘನದ ಒಂದು ಬಾಹು 10 ಸೆಂ. ಮೀ. ಇದ್ದರೆ, ಅದರ ಗಾತ್ರವು . . . . ಆಗಿರುತ್ತದೆ.

a 100 ಘ ಸೆಂ. ಮೀ.
b. 600 ಘ. ಸೆಂ. ಮೀ.
c. 1000 ಘ. ಸೆಂ. ಮೀ.
d. 30 ಘ. ಸೆಂ. ಮೀ.

9. ಈ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಬಹುಪದ ಬೀಜೋಕ್ತಿಯನ್ನು ಆರಿಸಿರಿ.

a. $x^{1} + 7x^{-2} + 4x^{-1} + x$ b. $x^3 + x + 7$ c. $\frac{x}{\sqrt{5}} + 1$ d $x^{2/3}y + 8x^{1/2} + 1$

10. ಈ ಎರಡು ತ್ರಿಭುಜಗಳು ಕೆಳಗೆ ಕೊಟ್ಟಿರುವ ಯಾವ ಸಮಾನ ಸಿದ್ಧಾಂತಕ್ಕೆ ಒಳಪಟ್ಟಿದೆ.



a SSS (ಬಾಹು – ಬಾಹು – ಬಾಹು)
b. RHS (ಲಂಬ – ಕರ್ಣ – ಬಾಹು)
c. SAS (ಬಾಹು – ಕೋನ – ಬಾಹು)
d SAA (ಬಾಹು – ಬಾಹು – ಕೋನ)

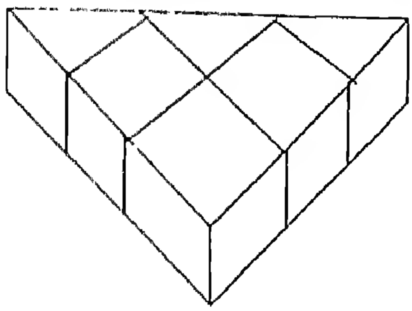
11 ಕೊಟ್ಟಿರುವ ಶ್ರೇಣಿಯನ್ನು ನೋಡಿರಿ 11, 21, 41, 61, 71 . . . . ಮುಂದಿನ ಸಂಖ್ಯೆಯು 91 ಆಗಿರುತ್ತದೆ, ಏಕೆಂದರೆ ಆ ಸಂಖ್ಯೆಗಳು . . . . ಆಗಿವೆ.

a. ಸಮ ಸಂಖ್ಯೆಗಳು
b ಬೆಸ ಸಂಖ್ಯೆಗಳು
c ಭಾಜ್ಯ ಅಪವರ್ತನಗಳು
d. ಅವಿಭಾಜ್ಯ ಅಪವರ್ತನಗಳು

12. 'A' ಮತ್ತು 'B' ಎರಡು ಗುಣಗಳು A X B ಯು 20 ಗಣಾಂಶಗಳನ್ನು ಹೊಂದಿದೆ, ಏಕೆಂದರೆ . . . .

a. n (A) = 5. n (B) = 4
b n (A) = 10. n (B) = 10
c. n (A) = 100. n (B) = 5
d. n (A) = 30. n (B) = -10

13 ಈ ಕೆಳಗಿನ ಪಟ್ಟಿಕದಲ್ಲಿ ಎಷ್ಟು ಪೂರ್ಣ ಘನಗಳಿವೆ ?



a 1 b 2 c. 3 d. 5

14 ಪರಸ್ಪರ ಒಂದಕ್ಕೊಂದು ಸಮಾಂತರವಾದ ಎರಡು ಗೆರೆಗಳನ್ನು ಹೇಗೆ ತೋರಿಸಬಹುದು ?

a 

b 

c 

d 

15. ಎರಡು ವಾಸ್ತವಿಕ ಸಂಖ್ಯೆಗಳ ಮೊತ್ತವು ಸೊನ್ನೆಯಾಗಿದೆ ಏಕೆಂದರೆ ಆ ಸಂಖ್ಯೆಗಳು . . . . . . ಆಗಿರುತ್ತವೆ.

a. ಸಮ ಸಂಖ್ಯೆಗಳು b. ಸಂಕಲನದ ಪ್ರತಿಲೋಮಗಳ ಸಂಖ್ಯೆಗಳು

c. ಬಾಗಲಬ್ಧ ಸಂಖ್ಯೆಗಳು d ಗುಣಾಕಾರದ ಪ್ರತಿಲೋಮಗಳ ಸಂಖ್ಯೆಗಳು

16 36097 ಇದರ ಬಹುಘಾತೀಯ ವಿಸ್ತಾರ ರೂಪವು ಈ ಕೆಳಗಿನದಾಗಿರುತ್ತದೆ?

a. $3 \times 10^5 + 6 \times 10^4 + 10 \times 10^2 + 9 \times 10^1 + 7 \times 10^0$

b $3 \times 10^4 + 6 \times 10^3 + 0 \times 10^2 + 9 \times 10^1 + 7 \times 10^0$

c $3 \times 10^5 + 6 \times 10^4 + 9 \times 10^3 + 7 \times 10^1$

d $3 \times 10^4 + 6 \times 10^3 + 9 \times 10^2 + 7 \times 10^1$

ಈ ಕೆಳಗಿನ ಸಮಸ್ಯೆಯನ್ನು ಓದಿ 17 ಮತ್ತು 18 ರ ಪ್ರಶ್ನೆಗಳನ್ನು ಉತ್ತರಿಸಿರಿ.

ತನ್ನ ಮಗ ಬಾಲೂನ ವಯಸ್ಸಿನ ಮೂರರಷ್ಟಕ್ಕಿಂತ ತಾಯಿ ಬೀನಾಳ ವಯಸ್ಸು 5 ಹೆಚ್ಚಿಗೆ ಇದೆ. ಹದಿನೈದು ವರ್ಷಗಳ ನಂತರ ಬೀನಾಳ ವಯಸ್ಸು ಬಾಲೂನ ವಯಸ್ಸಿಗಿಂತ ಎರಡರಷ್ಟಾಗುವದು.

17 ಮೇಲಿನ ದತ್ತಾಂಶಗಳಿಗೆ ಸೂಕ್ತವಾದ ಬೀಜೋಕ್ತಿಯನ್ನು ಆರಿಸಿರಿ

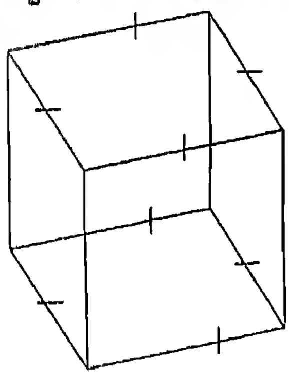
a $3x + 2y = 15$, $x - 3y = 5$ b $3x - y = 5$, $-2x + y = 15$ c. $x - 2y = 15$, $x - 3y = 5$ d $2x + y = 15$, $2x + y = 5$

18. ಈಗಿನ ಬಾಲೂನ ವಯಸ್ಸು . . . . ಆಗಿರುತ್ತದೆ.

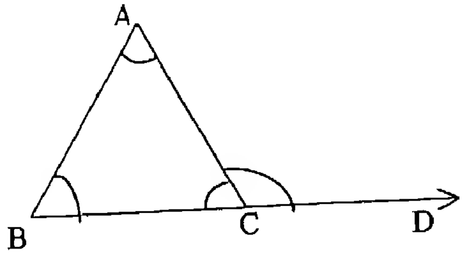
a 10 ವರ್ಷ b 15 ವರ್ಷ c. 5 ವರ್ಷ d. 20 ವರ್ಷ

19 ಕೆಳಗೆ ತೋರಿಸಿದ ಪಟ್ಟಕವು ಯಾವ ಪಾದ ಪಟ್ಟಕವಾಗಿರುತ್ತದೆ?

a ಷಡ್ಭುಜಾಕೃತಿ
b. ಅಷ್ಟಭುಜಾಕೃತಿ
c ಆಯತಾಕಾರ
d ಚೌಕ



ಈ ಕೆಳಗಿನ ಚಿತ್ರವನ್ನು ನೋಡಿ 20 ಮತ್ತು 21 ರ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.



20. ಬಾಹ್ಯ ಕೋನವು . . . .

a. $\angle ABC$ b. $\angle ACD$ c. $\angle DCB$ d $\angle CBA$

21. ಮೇಲಿನ ಚಿತ್ರದಲ್ಲಿ ಪೂರಕ ಕೋನಗಳು . . . . ಆಗಿರುತ್ತವೆ.

a. ∠ A, ∠ B b ∠ B, ∠ C c ∠ C, ∠ ACD d. ∠ A, ∠ ACD

22. ವಾಸ್ತವಿಕ ಸಂಖ್ಯೆಗಳು ಭಾಗಾಕಾರದಲ್ಲಿ ಅನ್ವಯಿಸುವುದಿಲ್ಲ, ಏಕೆಂದರೆ ಭಾಗಾಕಾರವು . . . .

a. ಋಣ ಸಂಖ್ಯೆಗಳಿಂದ ಭಾಗಿಸಲ್ಪಡುವುದಿಲ್ಲ b. ಸೊನ್ನೆಯಿಂದ ಭಾಗಹೋಗುವುದಿಲ್ಲ

c. ∞ – ಯಿಂದ ಭಾಗ ಹೋಗುವುದಿಲ್ಲ d. ಅಭಾಗಲಬ್ಧ ಸಂಖ್ಯೆಯಿಂದ ಭಾಗಿಸಲ್ಪಡುವುದಿಲ್ಲ

23. ϕ ವನ್ನು ಹಾಗೂ ನಡುವಿನ ಸಂಬಂಧವೆಂದು ಪರಿಗಣಿಸಲಾಗಿದೆ, ಏಕೆಂದರೆ . . . .

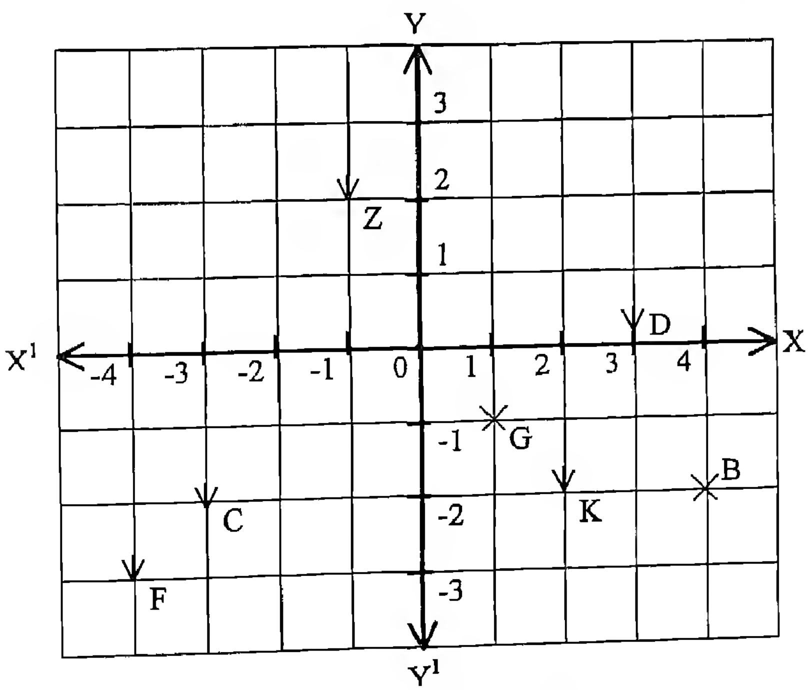
a. ϕ ನಲ್ಲಿ ಯಾವುದೇ ಅಂಶಗಳಿರುವದಿಲ್ಲ b. ϕಯು ಪ್ರತಿಯೊಂದು ಗಣದ ಉಪಗಣವಾಗಿದೆ

c. ϕ ಯು ಪ್ರತಿಯೊಂದು ಗಣದ ನಿರ್ದಿಷ್ಟ ಉಪಗಣವಾಗಿದೆ d. ϕ ಯು ವಿಶ್ವಗಣವಾಗಿದೆ

24. ಈ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಶೂನ್ಯ ಬಹುಪದ ಬೀಜೋಕ್ತಿಯನ್ನು ಆರಿಸಿರಿ.

a. $3x^0 + 0x^2 + 0$ b. $x + \frac{2}{5}$ c. $0x^1 + 7x^0$ d. $0x^1 + 0x^0$

ನಕ್ಷೆಯನ್ನು ಸರಿಯಾಗಿ ವೀಕ್ಷಿಸಿ 25 ರಿಂದ 28 ರ ವರಗಿನ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.



25 (-4, -3) ಈ ಬಿಂದುವಿನ ಸ್ಥಾನವು ಈ ಕೆಳಗಿನದಾಗಿದೆ.

a F b. K c. B d. A

26 'K' ಯಿಂದ ವ್ಯಕ್ತವಾಗುವ ಬಿಂದುವು ಇದಾಗಿದೆ.

a (-2, 0) b (2, 0) c (2, -2) d. (-2, 2)

27 X - ಅಕ್ಷದಲ್ಲಿರುವ ಬಿಂದುವು ಇದಾಗಿದೆ.

a (-3, 2) b (0, 3) c (3, 0) d (0, –8)

28 X = -1 ರ ರೇಖೆಯ ಮೇಲಿರುವ ಬಿಂದುವು . . . .

a F b K c G d. Z

29. ಸಿಲಿಂಡರನ ಎತ್ತರವು ಅದರ ತ್ರಿಜ್ಯದ ಎರಡರಷ್ಟಿದೆ. ಅದರ ತ್ರಿಜ್ಯವು X ಆಗಿದ್ದರೆ, ಅದರ ಗಾತ್ರವು . . . . ಆಗಿದೆ.

a Πx^2 b $2\Pi x^3$ c. Πx d. $4\Pi x^2$

30. ಎರಡು ರೇಖೆಗಳು ಛೇದಿಸುವುದರಿಂದ ಉಂಟಾದ ನಾಲ್ಕು ಕೋನಗಳಲ್ಲಿ ಒಂದು ಲಂಬ ಕೋನವಾಗಿದ್ದರೆ, ಇನ್ನುಳಿದ ಕೋನಗಳು . . . . ಆಗಿರುತ್ತವೆ.

a. ಅಧಿಕ ಕೋನಗಳು b. ಲಘು ಕೋನಗಳು c. ಲಂಬ ಕೋನಗಳು d. ಪೂರಕ ಕೋನಗಳು

31. $x - 2y$, $y - 2z$, $z - 2x$ ಈ ಬೀಜೋಕ್ತಿಗಳ ಮೊತ್ತಕ್ಕೆ $x + y + z$ ಬಹುಪದ ಬೀಜೋಕ್ತಿಯನ್ನು ಸೇರಿಸಿದಾಗ ಉಂಟಾಗುವ ಮೊತ್ತವು ಇದಕ್ಕೆ ಸಮಾನವಾಗಿರುತ್ತದೆ.

a. $x + y + z$ b. 0 c. $-(x + y + z)$ d. $-z$

ಕೆಳಗೆ ಕೊಟ್ಟಿರುವ ಅಂಕಿ ಅಂಶಗಳನ್ನು ಓದಿ, **32** ಹಾಗೂ **33** ರ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.

ಒಂದು ಪರೀಕ್ಷೆಯಲ್ಲಿ 50 ಪ್ರಶ್ನೆಗಳಿದ್ದರೆ ಪ್ರತಿಯೊಂದು ಸರಿ ಉತ್ತರಕ್ಕೆ 2 ಹೆಚ್ಚಿನ ಅಂಕಗಳನ್ನು ಹಾಗೂ ಪ್ರತಿಯೊಂದು ತಪ್ಪು ಉತ್ತರಕ್ಕೆ ಒಂದು ಅಂಕವನ್ನು ಕಡಿಮೆ ಮಾಡಲಾಗುವುದು, ಅಬ್ದುಲ್ಲಾ ಎಲ್ಲಾ 50 ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿ ಒಟ್ಟು 76 ಅಂಕಗಳನ್ನು ಪಡೆದಿದ್ದಾನೆ.

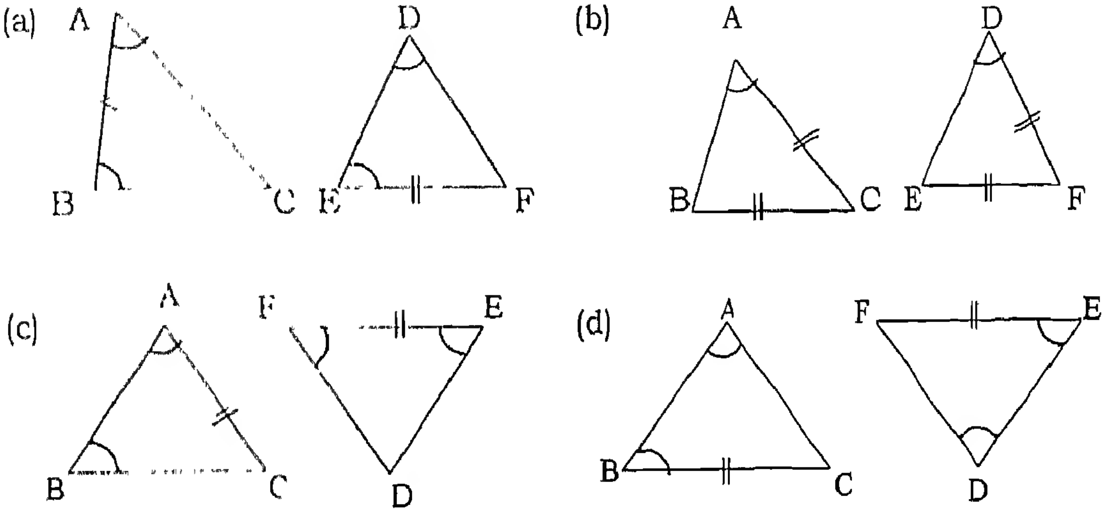
32. ಅಬ್ದುಲ್ಲಾನುಗಳಿಸಿದ ಒಟ್ಟು ಅಂಕಗಳು . . . . .

a. $x + y = 76$ b. $2x + y = 76$ c. $2x - y = 76$ d. $-2x + y = 76$

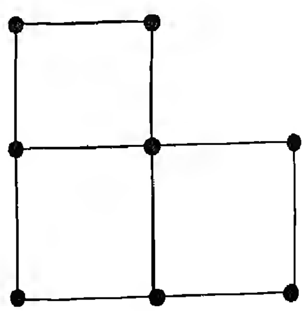
33. ಸರಿಯಾಗಿ ಉತ್ತರಿಸಿದ ಪ್ರಶ್ನೆಗಳು

a. 42 b. 26 c. 38 d. 8

34. ΔABC ಮತ್ತು ΔDEF ಎರಡು ತ್ರಿಭುಜಗಳಿದ್ದು ಆದರಲ್ಲಿ ಎರಡು ಕೋನಗಳು ಮತ್ತು ಒಂದು ಜೊತೆ ಬಾಹುಗಳು ಸರ್ವಸಮವಾಗಿವೆ. ಈ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಯಾವವು ಸರ್ವಸಮ ಜೋಡಿಗಳಾಗಿವೆ.?



35. ಕೆಳಗಿನ ಚಿತ್ರದಲ್ಲಿ 10 ಬೆಂಕಿ ಕಡ್ಡಿಗಳಿಂದ 3 ಚೌಕಗಳನ್ನು ರಚಿಸಲಾಗಿದೆ. ಎಷ್ಟು ಕಡಿಮೆ ಕಡ್ಡಿಗಳನ್ನು ತೆಗೆದಾಗ 2 ಚೌಕಗಳು ಉಂಟಾಗುತ್ತವೆ.



a. 3 b. 2 c. 1 d. 4

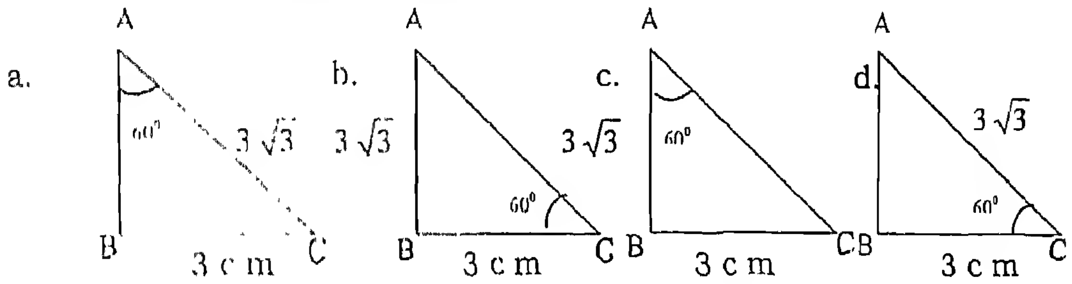
36. 'A' ಮತ್ತು 'B' ಎರಡು ಗಣಗಳಿದ್ದು, ಆದರೆ ಆದರಲ್ಲಿ A ದಿಂದ B ಅಥವಾ B ದಿಂದ A ಗೆ ಸಂಬಂಧ ಸಾಧ್ಯವಿಲ್ಲ, ಇದಕ್ಕೆ ಕಾರಣವೇನೆಂದರೆ . . . .

a. $A \cap B = \oint$ b. $A = \oint, B = \oint$ c. $A \neq \oint, B \neq \oint$ d. $A \cap B = A$

ಈ ಕೆಳಗೆ ಕೊಟ್ಟಿರುವ ಅಂಕಿ ಅಂಶಗಳನ್ನು ಓದಿ 37 ಹಾಗೂ 38 ರ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.

ಏಣಿಯ ಉದ್ದವು $3\sqrt{3}$ ಸೆಂ. ಮೀ. ಆಗಿದ್ದು ಗೋಡೆಗೆ ವಾಲಿಕೊಂಡಿದೆ. ಏಣಿಯ ಕೆಳತುದಿಯು ಭೂಮಿಗೆ ಸಮಾನವಾಗಿ 3 ಸೆಂ.ಮೀ. ದೂರದಿಂದ 60^0 ಕೋನದಲ್ಲಿರುತ್ತದೆ.

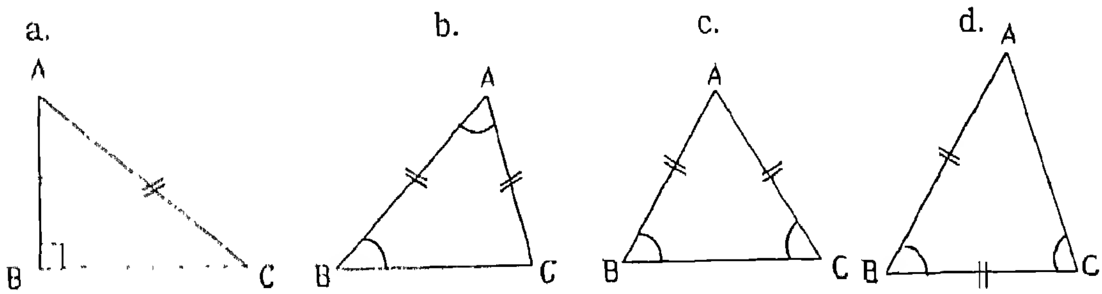
37 ಮೇಲಿನ ಹೇಳಿಕೆಯ ಪ್ರಕಾರ ಈ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಯಾವುದು ಸರಿಯಾದ ರೇಖಾ ಚಿತ್ರವಾಗಿದೆ ?



38 ಗೋಡೆಯಿಂದ ಏಣಿಯ ದೂರ 3 ಸೆಂ.ಮೀ. ಇರುತ್ತದೆ. ಗೋಡೆಯ ಎತ್ತರ ....

a. $3\sqrt{2}$ ಸೆಂ.ಮೀ. b. $2\sqrt{3}$ ಸೆಂ.ಮೀ. c. 3 ಸೆಂ.ಮೀ. d. 6 ಸೆಂ.ಮೀ.

39 ಸಮದ್ವಿ ಬಾಹು ತ್ರಿಭುಜವನ್ನು ಈ ಕೆಳಗಿನಂತೆ ಸೂಚಿಸಬಹುದು.



40. ಒಂದು ಪಕ್ಷ $\overleftrightarrow{CD} \perp \overleftrightarrow{AB}$ ಆದರೆ B ಯು $\overleftrightarrow{CD}$ ಮೇಲೆ ಒಂದು ಬಿಂದುವಾಗಿದೆ. ಹಾಗಾದರೆ $\angle ABD$ ಯು .... ಕೋನವಾಗಿರುತ್ತದೆ.

a. 30^0 b. 60^0 c. 90^0 d. 100^0

41. ಒಂದು ಪಕ್ಷ P(x) ಮತ್ತು Q(x) ಎರಡು 3ನೇ ಘಾತಾಂಶದ ಬೀಜೋಕ್ತಿಗಳಾದರೆ, ಅವುಗಳ ಮೊತ್ತದ ಘಾತಾಂಕವು .... ಆಗಿರುತ್ತದೆ.

a. ≤ 3 b. < 3 c. 3 d > 3

ಈ ಕೆಳಗಿನ ಹೇಳಿಕೆಯನ್ನು ಸರಿಯಾಗಿ ಓದಿ 42 ಹಾಗೂ 43 ರ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.

ತ್ರಿಭುಜದ ಕ್ಷೇತ್ರವನ್ನು ಹೆಚ್ಚಿಸಿದಾಗ ಅದರ ವಿಸ್ತೀರ್ಣವು 25 ಪಟ್ಟು ಹೆಚ್ಚಾಗುತ್ತದೆ.

42. ಮೂಲ ತ್ರಿಭುಜ ಹಾಗೂ ವಿಸ್ತರಿಸಿದ ತ್ರಿಭುಜಗಳ ಬಾಹುಗಳ ಉದ್ದವು . . . . . . ಈ ಅನುಪಾತದಲ್ಲಿರುತ್ತದೆ.

a. 1 : 25 b 25 : 1 c. 1 : 5 d. 5 : 1

43. ಮೂಲ ತ್ರಿಭುಜದ ಒಂದು ಬಾಹುವಿನ ಉದ್ದವು 7 ಸೆಂ.ಮೀ. ಆಗಿದ್ದರೆ, ವಿಸ್ತರಿಸಿದ ತ್ರಿಭುಜದ ಅನುರೂಪ ಬಾಹುವಿನ ಉದ್ದವು . . . . ಆಗಿರುತ್ತದೆ.

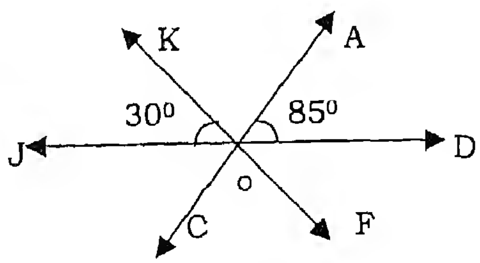
a. 7 b. 35 c. 2 d. 12

44. ಎರಡು ಜೋಡಿ ಸಮೀಕರಣಗಳಿಂದ ಬಂದ ಉತ್ತರವು ನಕ್ಷೆಯಲ್ಲಿ $x = k$, $y = u$ ಆಗಿರುತ್ತದೆ ಇವನ್ನು ಈ ಕೆಳಗಿನಂತೆ ಸೂಚಿಸಲಾಗುತ್ತದೆ.

a. (K, U) b. (U, K) c. (k, u) d. (u, k)

45. ಕೆಳಗಿನ ರೇಖಾಚಿತ್ರದಲ್ಲಿ ಎರಡು ಕೋನಗಳನ್ನು ಕೊಡಲಾಗಿದೆ, $\angle COF$ ಕೋನವು . . . . . ಗೆ ಸಮನಾಗಿರುತ್ತದೆ.

a. 65^0
b. 30^0
c. 85^0
d. 90^0



46. ಘನದ ಗಾತ್ರವು ಹಾಗೂ ಆದರ ಪೂರ್ಣ ಮೇಲ್ಮೈ ಕ್ಷೇತ್ರವು ಸಮಾನವಾಗಿದ್ದರೆ, ಪ್ರತಿಯೊಂದು ತುದಿಯ ಉದ್ದವು ಇದಾಗಿರುತ್ತದೆ.

a. 36 b. 6 c. 0 d. 1

47. ಒಂದು ಪಕ್ಷ $\overleftrightarrow{AB}$ ಮತ್ತು $\overleftrightarrow{CD}$ ರೇಖೆಗಳು 'O' ಬಿಂದುವಿನಲ್ಲಿ ಛೇಧಿಸಿದರೆ, $\angle AOD$ ಕೋನವು $\angle DOB$ ಯು ಎರಡಷ್ಟಾದರೆ, $\angle COB$ ದ ಅಳತೆಯು ಈ ಕೆಳಗಿನ ಕೋನಕ್ಕೆ ಸಮನಾಗಿರುತ್ತದೆ.

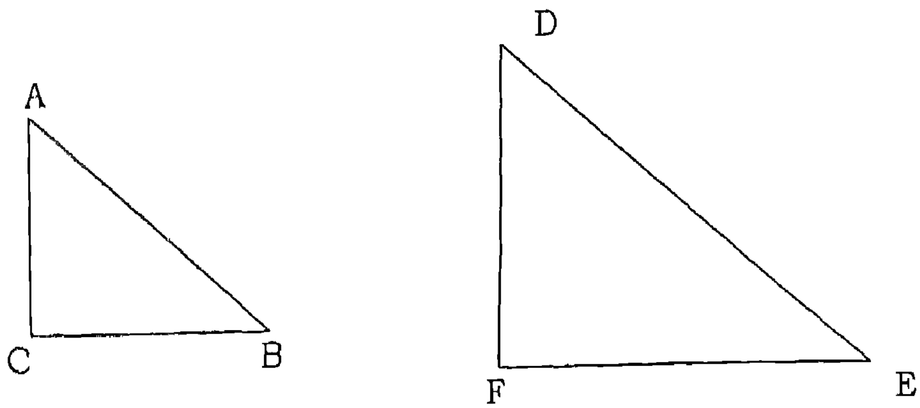
a. $2 \angle DOB$ b. $2 \angle AOB$ c. $\angle AOD$ d. $\angle DOB$

48. 3 ಸೆಂ.ಮೀ X 3 ಸೆಂ.ಮೀ X 6 ಸೆಂ.ಮೀ. ಈ ಅಳತೆಯ ಆಯತದಲ್ಲಿ 3 ಸೆಂ.ಮೀ. ನ ಎಷ್ಟು ಘನಗಳಿವೆ ?

a. 18 b. 36 c 3 d. 2

ಕೆಳಗಿನ ಹೇಳಿಕೆಯನ್ನು ಸರಿಯಾಗಿ ಓದಿ 49 ಹಾಗೂ 50 ರ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.

12 ಸೆಂ.ಮೀ. ಉದ್ದದ ಕೋಲು ಭೂಮಿಯ ಮೇಲೆ 8 ಸೆಂ.ಮೀ. ನೆರಳನ್ನು ಉಂಟುಮಾಡುತ್ತದೆ. ಅದೇ ರೀತಿಯಾಗಿ ಒಂದು ಗೋಪುರವು ಭೂಮಿಯ ಮೇಲೆ 40 ಮೀ. ಉದ್ದದ ನೆರಳನ್ನು ಉಂಟುಮಾಡುತ್ತದೆ. ಈ ಅಂಕಿ ಅಂಶಗಳ ಚಿತ್ರವು ಕೆಳಗಿನಂತಿರುತ್ತದೆ.



49. ಕೊಟ್ಟಿರುವ ಆಕೃತಿಯಲ್ಲಿಯ ಎರಡು ತ್ರಿಭುಜಗಳು ಈ ರೀತಿಯಾಗಿವೆ.

a. ಸಮರೂಪತೆ ಹೊಂದಿವೆ b. ಸಮವಾಗಿವೆ

c. ಸಮದ್ವಿ ಬಾಹು ತ್ರಿಭುಜಗಳಾಗಿವೆ d. ಸಮಬಾಹು ತ್ರಿಭುಜಗಳಾಗಿವೆ

50. ಗೋಪುರದ ಎತ್ತರವನ್ನು ತಿಳಿಸುವ ಸೂಕ್ತವಾದ ಅನುಪಾತವು ಈ ಕೆಳಗಿನವಾಗಿರುತ್ತದೆ.

a. $\frac{AB}{DF} = \frac{AC}{DE}$ b. $\frac{AB}{BC} = \frac{DE}{EF}$ c. $\frac{AC}{EF} = \frac{AB}{DE}$ d. $\frac{AC}{DF} = \frac{CB}{FE}$

APPENDIX – II

ANSWER SHEET

ವಿದ್ಯಾರ್ಥಿಯ ಹೆಸರು :

ಶಾಲೆಯ ಹೆಸರು :

ಲಿಂಗ :

ಜಾತಿ : ಪ. ಜಾ. / ಪ. ಪಂ. / ಇತರರು

ಪಾಲಕರ ಉದ್ಯೋಗ :

ವಾರ್ಷಿಕ ಉತ್ಪನ್ನ :

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
1		11		21		31		41	
2		12		22		32		42	
3		13		23		33		43	
4		14		24		34		44	
5		15		25		35		45	
6		16		26		36		46	
7		17		27		37		47	
8		18		28		38		48	
9		19		29		39		49	
10		20		30		40		50	

APPENDIX – III

SCORING KEY

OBSERVATION	
Item. No.	Answer
1	c
5	b
9	b
13	c
19	d
24	a
25	a
26	c
27	c
28	d

CODING	
Item No.	Answer
2	b
6	d
10	c
14	b
20	b
21	c
29	b
34	d
39	c
44	c

INFERENCE	
Item. No.	Answer
3	c
7	b
11	d
15	b
22	b
30	c
35	b
40	c
45	a
47	a

APPLICATION	
Item. No.	Answer
4	c
8	c
12	a
16	b
23	b
31	b
36	a
41	a
46	b
48	d

PROBLEM – SOLVING	
Item. No.	Answer
17	c
18	a
32	c
33	a
37	d
38	a
42	c
43	b
49	a
50	d

APPENDIX – IV

AN ACHIEVEMENT TEST IN MATHEMATICS

Std : IX

Time : 1 hr.

ಸೂಚನೆಗಳು : –

1 ಎಲ್ಲಾ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಗಳನ್ನು ಕೊಟ್ಟಿರುವ ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿ ಉತ್ತರಿಸಿರಿ ಮತ್ತು ಪ್ರಶ್ನೆಪತ್ರಿಕೆಯಲ್ಲಿ ಏನೂ ಬರೆಯಬೇಡಿರಿ.

2 ಯಾವುದೇ ಪ್ರಶ್ನೆಯ ಉತ್ತರವನ್ನು ತಿದ್ದುಪಡಿ ಮಾಡಬೇಡಿರಿ.

3 ಪ್ರತಿಯೊಂದು ಪ್ರಶ್ನೆಯನ್ನು ಗಮನವಿಟ್ಟು ಓದಿರಿ ಹಾಗೂ ಅದಕ್ಕೆ ಕೊಟ್ಟಿರುವ ನಾಲ್ಕು ಬೇರೆ ಬೇರೆ ಉತ್ತರಗಳಲ್ಲಿ ಸರಿಯಾದುದನ್ನು ಆಯ್ಕೆಮಾಡಿ ಅದರ ಇಂಗ್ಲೀಷ್ ಅಕ್ಷರವನ್ನು ಉದಾ: (a) ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿರುವ ಆ ಪ್ರಶ್ನೆಯ ಮುಂದೆ ಬರೆಯಿರಿ.

4 ಎರಡೂ ವಿಭಾಗಗಳಿಗೆ ಕೂಡಿ 3 ತಾಸು ಅವಧಿಯಿದೆ. ವಿಭಾಗ 1 ರ ಪ್ರಶ್ನೆಗಳಿಗೆ ಒಂದು ತಾಸಿಗಿಂತ ಮೊದಲೇ ಉತ್ತರಿಸಿ ಮುಗಿದಲ್ಲಿ ವಿಭಾಗ 2 ರ ಪ್ರಶ್ನೆಗಳನ್ನು ಉತ್ತರಿಸಲು ಪ್ರಾರಂಭಿಸಬಹುದು.

ಉದಾಹರಣೆ : 1. ಒಂದು ಬಿಂದುವಿನ ಸುತ್ತಲೂ ಉಂಟಾಗುವ ಕೋನದ ಅಳತೆ ....

a 90 ಅಂಶ b. 180 ಅಂಶ c. 360 ಅಂಶ d 365 ಅಂಶ

ಈ ಪ್ರಶ್ನೆಗೆ ಸರಿಯಾದ ಉತ್ತರ 360 ಅಂಶ, ಆಗಿದೆ ಇದನ್ನು 'c' ಕ್ರಮ ಸಂಖ್ಯೆಯಲ್ಲಿ ಕಾಣಬಹುದು ಆದ್ದರಿಂದ ನಿಮ್ಮ ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿ ಪ್ರಶ್ನೆ 1 ರ ಮುಂದೆ 'c' ಕ್ರಮ ಸಂಖ್ಯೆಯನ್ನು ಈ ಕೆಳಗೆ ಕೊಟ್ಟಿರುವಂತೆ ಬರೆಯಿರಿ.

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರಗಳು
1	c
2	
3	
4	

1 $A \cup (B \cup C) = (A \cup B) \cup C$ ಇದು ಗಣಗಳ ಯಾವ ನಿಯಮವನ್ನು ಸೂಚಿಸುತ್ತದೆ?

a. ಸಹವರ್ತನೀಯ ನಿಯಮ

b. ಪರಿವರ್ತನೀಯ ನಿಯಮ

c. ವಿಭಾಜಕ ನಿಯಮ

d ಡಿಮೋರ್ಗಾನ್‌ನ ನಿಯಮ

2. ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಅಚಿತಯುಗ್ಮವು ——— ಆಗಿದೆ.

a. (a, b) b. {a, b) c. (a, b} d. {b, a)

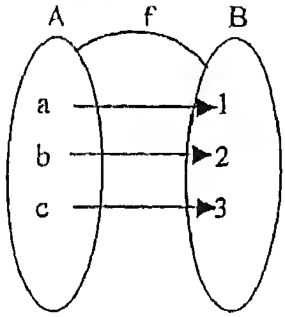
3 ಇಂಜೆಕ್ಟೀವ್ ಉತ್ಪನ್ನವನ್ನು ——————— ಉತ್ಪನ್ನ ಎಂದು ಕರೆಯುತ್ತಾರೆ.

a ಒಂದು–ಒಂದು ಉತ್ಪನ್ನ b. ಮೇಲಣ ಉತ್ಪನ್ನ
c ಅನನ್ಯತಾ ಉತ್ಪನ್ನ d. ಸ್ಥಿರಾಂಕ ಉತ್ಪನ್ನ

4 a ಮತ್ತು b ಇವುಗಳ ಅನುಪಾತವನ್ನು ಸೂಚಿಸುವ ಕ್ರಮ ————

a a + b b a – b c. a b d a · b

5. ಈ ಕೆಳಗಿನ ಚಿತ್ರವು ಯಾವ ಉತ್ಪನ್ನವನ್ನು ಸೂಚಿಸುತ್ತದೆ?



a. ಒಂದು–ಒಂದು ಉತ್ಪನ್ನ b ಮೇಲಣ ಉತ್ಪನ್ನ
c ಅನನ್ಯತಾ ಉತ್ಪನ್ನ d. ಸ್ಥಿರಾಂಕ ಉತ್ಪನ್ನ

6 11,21,41,61,71,91, ... ಈ ಶ್ರೇಣಿಯಲ್ಲಿ ಬರುವ ಎಲ್ಲಾ ಸಂಖ್ಯೆಗಳು ——— ಆಗಿವೆ.

a ಸಮ ಸಂಖ್ಯೆಗಳು b. ಬೆಸ ಸಂಖ್ಯೆಗಳು
c ಬಾಜ್ಯ ಅಪವರ್ತನಗಳು d. ಅವಿಬಾಜ್ಯ ಅಪವರ್ತನಗಳು

7 A ಮತು B ಎರಡು ವಾಸ್ತವಿಕ ಸಂಖ್ಯೆಗಳ ಮೊತ್ತವು ಸೊನ್ನೆಯಾಗಿದೆ, ಹಾಗಾದರೆ ಆ ಸಂಖ್ಯೆಗಳು ——— ಆಗಿರುತ್ತವೆ.

a. ಸಮ ಸಂಖ್ಯೆಗಳು b. ಭಾಗಲಬ್ಧ ಸಂಖ್ಯೆಗಳು
c. ಸಂಕಲನದ ಪ್ರತಿಲೋಮಗಳ ಸಂಖ್ಯೆಗಳು d. ಗುಣಾಕಾರದ ಪ್ರತಿಲೋಮಗಳ ಸಂಖ್ಯೆಗಳು

8. A ಮತ್ತು B ಎರಡು ಗಣಗಳಾಗಿವೆ, A X B ಯು 4 ಗಣಾಂಶಗಳನ್ನು ಹೊಂದಿದೆ ಏಕೆಂದರೆ ————.

a. n(A)=2 , n(B)=2 b n(A)=10 , n(B)=0
c. n(A)=1 , n(B)=3 d. n(A)=30 , n(B)= –5

9 A = {1,2,3}, B = {5,6} ಆದರೆ A X B ಗಣಕ್ಕೆ ಸೇರಿದ ಎಲ್ಲ ಅಣಿತಯುಗ್ಮಗಳ ಸಂಖ್ಯೆಯು ________ ಆಗಿದೆ.

a. 8 b. 6 c. 9 d. 5

10 $\frac{x}{y} = \frac{m}{n}$ ನಲ್ಲಿ y ಮತ್ತು m ಗಳನ್ನು ಏನೆಂದು ಕರೆಯುತ್ತಾರೆ?

a. ಮಧ್ಯಾನುಪಾತೀಯ ಪದಗಳು b. ಸಮಾನುಪಾತಗಳು

c. ಮಧ್ಯಪದಗಳು d. ಅಂತ್ಯ ಪದಗಳು

11 A = {1,2,3,4}, B = {3,4,5,6} ಆದರೆ $A \cap B$ ದ ಬೆಲೆ ಎಷ್ಟು?

a. {3,4} b. {1,2,3} c. {1,2,3,4,5,6} d. {3,4,5,6}

12 ϕ ಯನ್ನು x ಮತ್ತು y ನಡುವಿನ ಸಂಬಂಧವೆಂದು ಪರಿಗಣಿಸಲಾಗಿದೆ. ಏಕೆಂದರೆ ________.

a. ϕ ಯು ರಿಕ್ತಗಣವಾಗಿದೆ.

b. ϕ ನಲ್ಲಿ ಯಾವುದೇ ಅಂಶಗಳಿರುವುದಿಲ್ಲ.

c. ϕ ಯು ಪ್ರತಿಯೊಂದು ಗಣದ ಉಪಗಣವಾಗಿದೆ.

d. ϕ ಯು ಪ್ರತಿಯೊಂದು ಗಣದ ನಿರ್ದಿಷ್ಟ ಉಪಗಣವಾಗಿದೆ.

13 $3a + b < 2a$ ಆದಾಗ ಕೆಳಗಿವುಗಳಲ್ಲಿ ಯಾವ ಸಂಬಂಧವು ಸರಿ ಇದೆ ?

a. $5a > b$ b. $5a < -b$ c. $a < -b$ d. $a < b$

14 ವಾಸ್ತವಿಕ ಸಂಖ್ಯೆಗಳು ಭಾಗಾಕಾರದಲ್ಲಿ ಅನ್ವಯಿಸುವುದಿಲ್ಲ ಏಕೆಂದರೆ ಭಾಗಾಕಾರವು ------.

a. ಋಣ ಸಂಖ್ಯೆಗಳಿಂದ ಭಾಗಿಸಲ್ಪಡುವುದಿಲ್ಲ b. ಸೊನ್ನೆಯಿಂದ ಭಾಗಹೋಗುವುದಿಲ್ಲ

c. ೧-ಯಿಂದ ಭಾಗಹೋಗುವುದಿಲ್ಲ d. ಅಭಾಗಲಬ್ದ ಸಂಖ್ಯೆಯಿಂದ ಭಾಗಿಸಲ್ಪಡುವುದಿಲ್ಲ

15 $(2x-3)^2$ನ್ನು ವಿಸ್ತರಿಸಿದಾಗ ಯಾವ ಪದ ಚರಾಕ್ಷರ(ಬೀಜಾಕ್ಷರ) ದಿಂದ ಹೊರತಾಗಿದೆ.

a. -4 b. -12 c. 9 d. -9

16. ಈ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ದ್ವಿಪದೋಕ್ತಿಯನ್ನು ಗುರುತಿಸಿರಿ.

a. x^2+1 b. 6 c. $x - y + 2$ d. 7pq

17. ಇವುಗಳಲ್ಲಿ ಬಹುಪದ ಬೀಜೋಕ್ತಿಯು ________ ಆಗಿದೆ.

a. $p^3+7p^2+4p^{-3}$ b. p^3+p+7

c. $\frac{p}{\sqrt{5}}+1$ d. $p^{2/3}q+8p^{1/2}+1$

18. $3p+3q=3(\quad)$ ಈ ಸಮೀಕರಣದಲ್ಲಿ ಬಿಟ್ಟ ಜಾಗವನ್ನು ಸೂಕ್ತವಾದ ಬೀಜೋಕ್ತಿಯಿಂದ ತುಂಬಿರಿ.

a. $p+q$ b. pq c. $p-q$ d. $p\div q$

19. $25a^2-1=[5a-1][\ldots\ldots]$

a. $5a-1$ b. $20a$ c. $6a$ d. $5a+1$

20. $x-2y$, $y-2z$, $z-2x$ ಈ ಬೀಜೋಕ್ತಿಗಳ ಮೊತ್ತಕ್ಕೆ $x+y+z$ ಬಹುಪದ ಬೀಜೋಕ್ತಿಯನ್ನು ಕೂಡಿದಾಗ ಉಂಟಾಗುವ ಮೊತ್ತವು ________ ಆಗಿರುತ್ತದೆ.

a. $-(2x+2y+2z)$ b. $-(x+y+z)$ c. 0 d. z

21. $(a+b+c)^2$ ಇದರ ವಿಸ್ತೃತರೂಪವು ________

a. $a^2+b^2+c^2+ab+bc+ca$ b. $a^2+b^2+c^2+2ab+2bc+2ca$

c. $a^2+b^2+c^2+2abc$ d. $a^2+b^2+c^2$

22. a^3-b^3 ________ ಆಗಿದೆ.

a. $(a-b)(a^2+ab+b^2)$ b. $(a+b)(a^2-ab+b^2)$

c. $a^3+b^3+3ab(a+b)$ d. $a^3-b^3-3ab(a-b)$

23. $3x^3\div 3x^3$ ಇದರ ಸಂಕ್ಷಿಪ್ತ ರೂಪ ________

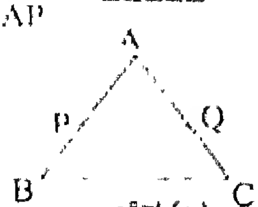
a. 0 b. -1 c. 1 d. $3x^3$

24. ಶಂಕುವಿನ ವಕ್ರಮೇಲ್ಮೈ ವಿಸ್ತೀರ್ಣವನ್ನು ತೆಗೆಯುವ ಸೂತ್ರ ________

a. Πrl b. $2\Pi rl$ c. $2\Pi r^2$ d. $4\Pi r^2$

25 ಚಿತ್ರ (a) ದಲ್ಲಿ $PQ \parallel BC$ ಆಗಿದೆ

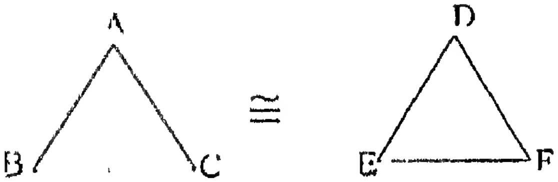
ಹಾಗಾದರೆ $\frac{AB}{AP}$ = ______



ಚಿತ್ರ(a)

a $\frac{AC}{AQ}$ b $\frac{BP}{AP}$ c $\frac{AC}{QC}$ d $\frac{AC}{AB}$

26



ಚಿತ್ರ (b)

ಈ ಮೇಲಿನ ತ್ರಿಭುಜಗಳು ಕೆಳಗೆ ಕೊಟ್ಟಿರುವ ಯಾವ ಸಮಾನ ಸಿದ್ಧಾಂತಕ್ಕೆ ಒಳಪಟ್ಟಿದೆ ?

a SSS (ಬಾಹು–ಬಾಹು–ಬಾಹು) b. RHS (ಲಂಬ–ಕರ್ಣ–ಬಾಹು)

c SAS (ಬಾಹು–ಕೋನ–ಬಾಹು) d SAA (ಬಾಹು–ಕೋನ–ಕೋನ)

27. ಚಿತ್ರ (b) ದಲ್ಲಿ Δ ABC ಮತ್ತು Δ DEF ಗಳು ________ ತ್ರಿಭುಜಗಳಾಗಿವೆ.

a. ಸಮರೂಪ ತ್ರಿಭುಜಗಳು b. ಸರ್ವಸಮ ತ್ರಿಭುಜಗಳು

c. ಸಮಬಾಹು ತ್ರಿಭುಜಗಳು d. ಸಮಾನ ತ್ರಿಭುಜಗಳು

28. ಚಿತ್ರ (c) ದಲ್ಲಿ ರೇಖೆಗಳು ______ ವಾಗಿವೆ.

ಚಿತ್ರ(c)

a ಲಂಬವಾಗಿವೆ b. ಸಮಾಂತರವಾಗಿವೆ

c. ಸಂಧಿಸಿವೆ (ಐಕ್ಯವಾಗಿವೆ) d. ಛೇದಿಸಿದೆ

29 [illegible] ?

a [illegible]
b ಆಯತಘನ
c [illegible]
d ತ್ರಿಕೋನಪಾದವುಳ್ಳಗೋಪುರ

30 [illegible] ಸೂತ್ರ ______ ಆಗಿದೆ.

a $\frac{4}{[illegible]}$ Π r[illegible]
b $\frac{2}{[illegible]}$ Π r[illegible]
c $\frac{1}{3} \Pi r^2 h$
d. $\frac{1}{3} B h$

31 [illegible] ಸರಿಯಾಗಿ ಮುಚ್ಚಿ ಅದನ್ನು ಬಿಡಿಸಿದಾಗ ಅದು [illegible]

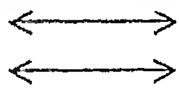
a [illegible]
b [illegible]ದಂತೆ
c. ಕಂಸದಂತೆ
d ತ್ರಿಜ್ಯಾಂತರಖಂಡದಂತೆ

32 [illegible] ಕಲಗಳಿರುತ್ತವೆ.

a 1
b 2
c 3
d. 4

33 [illegible] ಎರಡು ರೇಖೆಗಳನ್ನು ಗುರುತಿಸಿರಿ?

a 

b. 

c 

d 

34 [illegible] ಕಂಡು ಹಿಡಿಯುವ ಸೂತ್ರವು ______

a B h
b ½ B h
c P h
d 2 B + P h

35 Y [illegible] 4x ಈ ಸರಳರೇಖೆಯು ಹೊಂದಿರುವ ಗುಣದರ್ಮ __________

a ಆ ಸರಳರೇಖೆಯು x ಅಕ್ಷವನ್ನು 4 ಮಾನದಲ್ಲಿ ಕಡಿಯುತ್ತದೆ.
b ಆ ಸರಳರೇಖೆಯು y ಅಕ್ಷವನ್ನು 4 ಮಾನದಲ್ಲಿ ಕಡಿಯುತ್ತದೆ.
c ಆ ಸರಳರೇಖೆಯು x ಅಕ್ಷವನ್ನು –4 ಮಾನದಲ್ಲಿ ಕಡಿಯುತ್ತದೆ.
d ಆ ಸರಳರೇಖೆಯು ಮೂಲಬಿಂದುವಿನಲ್ಲಿ ಹಾಯ್ದು ಹೋಗುತ್ತದೆ.

36 Y [illegible] x + 3 ಈ ಗ್ರಾಫ್‌ನಲ್ಲಿ ಕೆಳಗಿನವುಗಳಲ್ಲಿ ಯಾವ ಬಿಂದುವು ಆ ಸರಳರೇಖೆಯ ಮೇಲೆ ಇರುವುದಿಲ್ಲ?

a (3, 6)
b. (0, -3)
c. (1, 4)
d. (-3, 0)

37 [illegible] ವಿಸ್ತೀರ್ಣವು ______

a [illegible] b ಅರ್ಧದಷ್ಟಾಗುವುದು

c [illegible] d ¼ ದಷ್ಟಾಗುವುದು

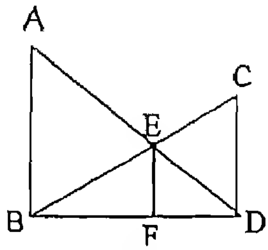
38 [illegible] ತ್ರಿ[illegible]ಗಳ ಎರಡು ಜೋಡಿಗಳನ್ನು ಈ ಕೆಳಗೆ ನೀಡಲಾಗಿದೆ [illegible]

a ABD, EFD [illegible] BCD, BEF

b ABD, EFD [illegible] AFB, CDC

c ABD, BCD [illegible] EFD, BEF

d EFD BCD [illegible] ABD, BEF

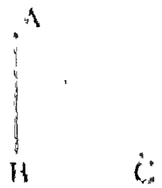


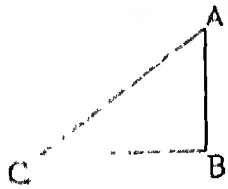
ಚಿತ್ರ (d)

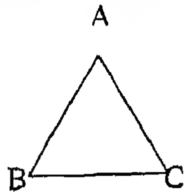
39 [illegible] ಘನಾಕೃತಿಯೆಂದರೆ __________

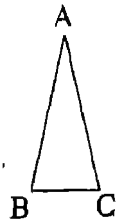
a [illegible] b [illegible] c. ಶಂಕು d. ಸಿಲಿಂಡರ್

40 [illegible] ತ್ರಿಭುಜವನ್ನು ಕಂಡು ಹಿಡಿಯಿರಿ.

a 

b 

c. 

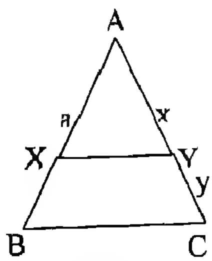
d. 

41 ಚಿತ್ರ (e) ದಲ್ಲಿ AX = a, XB = b, AY = x, YC = y

ಆದರೆ $\frac{a+b}{a} = \frac{[\ \ ]}{x}$

a $x + y$ b. $\frac{x}{y}$

c $\frac{x+y}{y}$ d $\frac{b}{y}$



ಚಿತ್ರ (e)

42 ಒಂದು ಘನಾಕಾರದ ಪೆಟ್ಟಿಗೆಯ ಘನಫಲವು 64 ಘನ ಅಡಿ ಇದ್ದರೆ ಅದರ ಒಂದು ಬದಿಯ ಉದ್ದವು (ಅಡಿಗಳಲ್ಲಿ) ________.

a. 64 b. 16 c. 4 d. 32

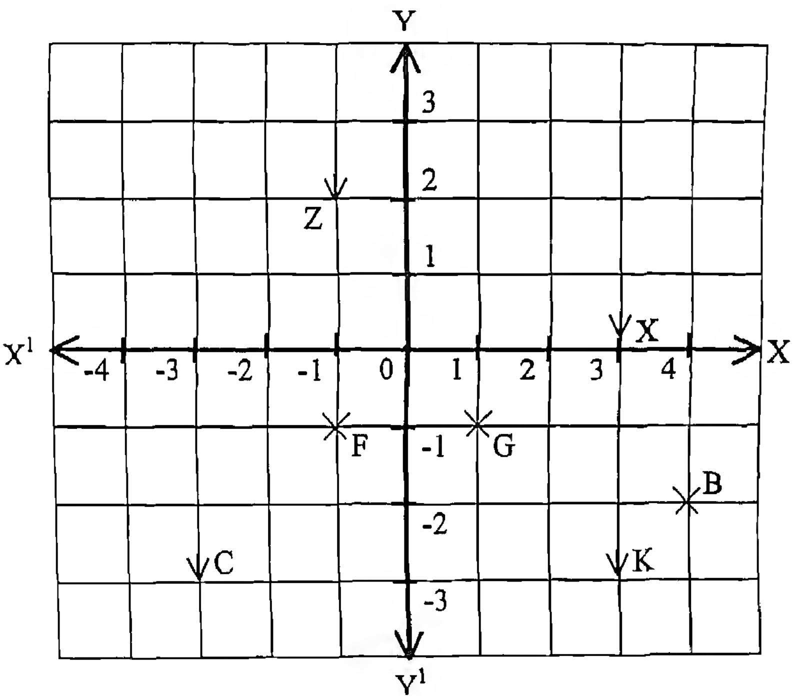
43 ಬಹುಮುಖ ಘನಗಳಿಗೆ ಆಯ್ಲರನ ಸೂತ್ರವು ________ ಆಗಿದೆ.

a. $F + V = E$ b. $F+V=E-2$
c. $F - V = E + 2$ d $F + V = E + 2$

44. ಸಿಲಿಂಡರ್‌ನ ಎತ್ತರವು ಅದರ ತ್ರಿಜ್ಯದ ಎರಡರಷ್ಟಿದೆ ಆದರೆ ತ್ರಿಜ್ಯವು X ಆಗಿದ್ದರೆ ಅದರ ಗಾತ್ರವು ______ ಆಗಿರುತ್ತದೆ.

a Πx^2 b $2\Pi x^3$ c. Πx d $4\Pi x^2$

ನಕ್ಷೆಯನ್ನು ಸರಿಯಾಗಿ ವೀಕ್ಷಿಸಿ 45 ರಿಂದ 48 ರ ವರಗಿನ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.



45. (-1, -1) ಈ ಬಿಂದುವಿನ ಸ್ಥಾನವು ಈ ಕೆಳಗಿನದಾಗಿದೆ.

a. F b K c. B d. A

46 K ಯಿಂದ ವ್ಯಕ್ತವಾಗುವ ಬಿಂದುವು ಇದಾಗಿದೆ.

a. (-2, 0) b (2, 0) c (3, -3) d. (-2, 2)

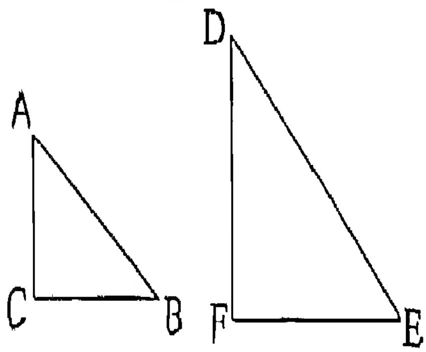
47. X ಯಿಂದ ವ್ಯಕ್ತವಾಗುವ ಬಿಂದುವು ಇದಾಗಿದೆ.

a. (-3, 2) b (0, 3) c (3, 1) d. (0, –3)

48. Z ದಿಂದ ವ್ಯಕ್ತವಾಗುವ ಬಿಂದುವು ಇದಾಗಿದೆ.

a. (-1, 2) b. (1, 1) c (1, 2) d (–2, 1)

49. ಕೆಳಗೆ ಕೋಟ್ಟಿರುವ ತ್ರಿಭುಜಗಳು ________ ಆಗಿವೆ.



a ಸಮರೂಪತೆ ಹೊಂದವೆ
b ಸಮವಾಗಿವೆ
c ಸಮದ್ವಿಬಾಹು ತ್ರಿಭುಜಗಳಾಗಿವೆ
d ಸಮಬಾಹು ತ್ರಿಭುಜಗಳಾಗಿವೆ

50 ಒಂದು ಗೋಪುರದಲ್ಲಿ ಅದರ ಇಳಿಜಾರಿಕೆಯ ಎತ್ತರವೆಂದರೆ ________

a ಶಿರೋಬಿಂದುವಿನಿಂದ ತಳಕ್ಕೆ ತೆಗೆದ ಲಂಬ

b. ಶಿರೋಬಿಂದುವಿನಿಂದ ಪಾದದ ಯಾವುದೇ ಬುಜಕ್ಕೆ ಎಳೆದ ಲಂಬ

c. ಶಿರೋಬಿಂದುವನ್ನು ಪಾದದ ಶಿರೋ (ಕೋನ) ಬಿಂದುಗಳನ್ನು ಕೂಡಿಸುವ ರೇಖೆ

d. ಶಿರೋಬಿಂದುವನ್ನು ಪಾದದ ಸುತ್ತಳತೆಯ ಮೇಲಿನ ಬೇಕದ ಬಿಂದುವನ್ನು ಕೂಡಿಸುವ ರೇಖೆ

APPENDIX – V

ANSWER SHEET

ವಿದ್ಯಾರ್ಥಿಯ ಹೆಸರು :

ವರ್ಗ :

ಶಾಲೆಯ ಹೆಸರು :

ವಿಭಾಗ :

ಲಿಂಗ :

ಹಳ್ಳಿ / ಪಟ್ಟಣ :

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	

APPENDIX – VI

SCORING KEY

ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ	ಪ್ರಶ್ನೆ ಸಂಖ್ಯೆ	ಉತ್ತರ
1	a	11	a	21	b	31	d	41	c
2	a	12	c	22	a	32	d	42	c
3	a	13	c	23	c	33	a	43	d
4	d	14	b	24	a	34	a	44	b
5	a	15	c	25	a	35	d	45	a
6	d	16	a	26	a	36	b	46	c
7	c	17	b	27	b	37	c	47	c
8	a	18	a	28	b	38	a	48	a
9	b	19	d	29	d	39	b	49	a
10	c	20	a	30	a	40	c	50	c

APPENDIX – VII

AN ATTITUDE SCALE TOWARDS MATHEMATICS

ಹೆಸರು :

ಲಿಂಗ : ಗಂಡು/ಹೆಣ್ಣು

ವರ್ಗ :

ಶಾಲೆಯ ಹೆಸರು :

ಪಟ್ಟಣ/ಗ್ರಾಮ :

ನಿರ್ದೇಶನಗಳು:

೧) ಪ್ರತಿಯೊಂದು ವಾಕ್ಯವನ್ನು ಗಮನವಿಟ್ಟು ಓದಿರಿ.

೨) ಪ್ರತಿಯೊಂದು ಮನೋಭಾವನೆಯ ವಾಕ್ಯದ ಮುಂದೆ ಐದು ಬಗೆಯ ಮನೋಭಾವನೆಗಳನ್ನು ಕೊಡಲಾಗಿದೆ. ಅವುಗಳೆಂದರೆ, 'ಯಾವಾಗಲೂ', 'ಮೇಲಿಂದಮೇಲೆ', 'ಯಾವಾಗಲಾದರೂ ಒಮ್ಮೆ', 'ಅಪರೂಪವಾಗಿ', 'ಯಾವಾಗಲೂ ಇಲ್ಲ'.

೩) ಅವುಗಳಲ್ಲಿ ನಿಮ್ಮ ಉತ್ತರವು 'ಯಾವಾಗಲೂ' ಎಂದರೆ, ಉತ್ತರ ಪತ್ರಿಕೆಯಲ್ಲಿ ಆ ಹೇಳಿಕೆಯ ಮುಂದೆ ☑ ಈ ಗುರುತನ್ನು ಹಾಕಿರಿ. ನಿಮ್ಮ ಉತ್ತರ 'ಯಾವಾಗಲಾದರೂ ಒಮ್ಮೆ' ಎಂದಾದರೆ ಅದರ ಕೆಳಗೆ ☑ ಚಿನ್ಹೆಯನ್ನು ಹಾಕಿರಿ. ಹೀಗೆಯೇ ಎಲ್ಲಾ ಹೇಳಿಕೆಗಳಿಗೆ ಉತ್ತರಿಸಿರಿ.

೪) ಒಂದು ಹೇಳಿಕೆಯ ಮುಂದೆ ಒಂದೇ ಚಿನ್ಹೆಯ ಗುರುತಿರಬೇಕು.

ಕ್ರ. ಸಂ.	ಮನೋಭಾವದ ಹೇಳಿಕೆಗಳು
	ಭಾಗ–I : Mathematics Teacher
1	ಗಣಿತವು ಅಂಕಿ ಸಂಖ್ಯೆಗಳಿಂದ ಕೂಡಿರುವದರಿಂದ ಅರ್ಥೈಸಿಕೊಳ್ಳುವದು ಸುಲಭ.
2.	ಗಣಿತವು ಆಸಕ್ತಿಯನ್ನು ಕೆರಳಿಸುವಂತ ವಿಷಯವಾಗಿದೆ.
3	ಗಣಿತವು ಹೆಚ್ಚು ಕ್ಲಿಷ್ಟತೆಯಿಂದ ಕೂಡಿರುವದರಿಂದ ತಲೆಬೋರ್ ಹಿಡಿಯುವಂತದ್ದಾಗಿದೆ.
4.	ಗಣಿತ ವಿಷಯವನ್ನು ತರಗತಿಯಲ್ಲಿ ಬೋಧನೆಯಿಂದ ತಪ್ಪಿಸಿಕೊಳ್ಳುವಂತಾಗುತ್ತದೆ.
5.	ಗಣಿತ ವಿಷಯಕ್ಕೆ ಹೆಚ್ಚಿನ ಸಮಯ ಕೊಟ್ಟು ಕೆಲಸ ಮಾಡುವದರಿಂದ ಹೆಚ್ಚಿನ ಸಮಯ ಕೊಟ್ಟು ಕೆಲಸ ಮಾಡುವದರಿಂದ ಹೆಚ್ಚಿನ ಗಣಿತ ಪಾಂಡಿತ್ಯವನ್ನು ಹೊಂದಬಹುದು.
6	ಗಣಿತವು ಹಳೆಯ ಮಾದರಿಯ ಕೆಲವು ವಿಷಯಗಳನ್ನು ಒಳಗೊಂಡಿರುವದರಿಂದ ತಲೆ ಹಿಡಿಯುವಂತದ್ದಾಗಿದೆ.
7	ಗಣಿತವು ಪ್ರಸ್ತುತ ಕಾಲಕ್ಕನುಗುಣವಾದಂತಹ ಹೊಸ ಮಾದರಿಯ ವಿಷಯವನ್ನು ಒಳಗೊಂಡಿಲ್ಲ.
8.	ರೇಖಾಗಣಿತದ ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸುವದರಿಂದ ಮನಸ್ಸು ಹೆಚ್ಚು ಸಂತುಷ್ಟಗೊಳ್ಳುತ್ತದೆ.
9.	ಗಣಿತವು ಹೆಚ್ಚಾಗಿ ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸುವ ವಿಷಯವನ್ನು ಹೊಂದಿರುವದರಿಂದ ನಿರಾಸಕ್ತಿಯನ್ನುಂಟು ಮಾಡುತ್ತದೆ.

ಕ್ರ. ಸಂ.	ಮನೋಭಾವದ ಹೇಳಿಕೆಗಳು
10	ಗಣಿತವು ಬೀಜಗಣಿತ, ರೇಖಾಗಣಿತ ವಿಷಯಗಳನ್ನು ಒಳಗೊಂಡಿರುವದರಿಂದ ವಿವಿಧ ಬಗೆಯ ವಿಷಯದ ಅಂಕಿ ಸಂಖ್ಯೆಗಳನ್ನು ತಿಳಿಯಲು ಸಹಾಯಕವಾಗಿದೆ.
11	ಗಣಿತದ ಬೋಧನೆಯಿಂದ ಮನಸ್ಸು ಹೆಚ್ಚು ಚುರುಕುಗೊಳ್ಳುವದು.
12	ಗಣಿತವು ಹೆಚ್ಚು ಅಂಕಿ ಸಂಖ್ಯೆಗಳಿಂದ ಕೂಡಿರುವದರಿಂದ ತರಗತಿಯ ಬೋಧನೆಯ ವೇಳೆ ಗೊಂದಲ ಉಂಟಾಗುತ್ತದೆ.
13	ತರಗತಿಯಲ್ಲಿ ಗಣಿತ ಬೋಧನೆಯು ಅಂಜಿಕೆಯನ್ನುಂಟು ಮಾಡುತ್ತದೆ.

ಭಾಗ–II : Methods of Teaching Mathematics

1 ಗಣಿತ ಬೋಧನೆಯನ್ನು ಗ್ರಾಫ್‌ಗಳ ಮೂಲಕ ಬೋಧಿಸುವದರಿಂದ ಅತ್ಯಂತ ಆಕರ್ಷಕವಾಗುವದು.

2 ಕೋನ, ತ್ರಿಕೋನ, ಗ್ರಾಫ್ ಸಹ್ಲೆ ಮುಂತಾದವುಗಳ ಬಳಕೆಯಾಗುವದರ ಮೂಲಕ ಗಣಿತ ಬೋದನೆಯು ಆಸಕ್ತಿಯನ್ನುಂಟು ಮಾಡುತ್ತದೆ.

3 ಬೀಜಗಣಿತದ ಸಮಸ್ಯೆಗಳ ಬೋಧನೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಕುತೂಹಲವನ್ನು ಕೆರಳಿಸುವಲ್ಲಿ ವಿಫಲವಾಗಿದೆ.

4 ರೇಖಾಗಣಿತದ ವಿಷಯವನ್ನು ಉಪಕರಣಗಳ ಮೂಲಕ ವಿದಾರ್ಥಿಗಳಿಗೆ ಬೋಧಿಸುವದರಿಂದ ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗುವದು.

5. ಗಣಿತ ವಿಷಯವನ್ನು ಕೇವಲ ಶಾಲೆಯ ಒಳಾಂಗಣ ಅಥವಾ ಕೊಠಡಿಯಲ್ಲಿ ಬೋಧಿಸುವದರಿಂದ ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗುವದಿಲ್ಲ.

6 ಗಣಿತದಲ್ಲಿ ಬರುವ ರೇಖಾಗಣಿತದ ವಿಷಯವನ್ನು ಪ್ರಮೇಯಗಳ ಮೂಲಕ ಬೋಧಿಸುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಆಸಕ್ತಿಯನ್ನು ಕೆರಳಿಸಲು ಸಹಾಯಕವಾಗಿದೆ.

7 ಗಣಿತ ಬೋಧನೆಯನ್ನು ಕ್ರಮಾನುಗತವಾಗಿ ಬೋಧಿಸುವದರಿಂದ ಬೋಧನೆಯು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗುವದು.

8 ಗಣಿತದಲ್ಲಿ ಬರುವ ಬೀಜಗಣಿತದ ಸಮಸ್ಯೆಗಳು ಹೆಚ್ಚು ಕ್ಲಿಷ್ಟತೆಯಿಂದ ಕೂಡಿರುವದರಿಂದ ಬೋಧನೆಯು ಯಶಸ್ವಿಯಾಗುವದಿಲ್ಲ.

9. ಗಣಿತ ವಿಷಯವನ್ನು ವಿವಿಧ ಮಾದರಿಗಳ ಮೂಲಕ ಬೋಧಿಸಲು ಹೆಚ್ಚು ಸಹಾಯಕವಾಗಿದೆ.

10. ಗಣಿತವು ಹೆಚ್ಚಾಗಿ ಪ್ರಾಯೋಗಿಕ ವಿಷಯವನ್ನು ಹೊಂದಿರುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ಆಸಕ್ತಿಯನ್ನು ಹೊಂದುವಂತೆ ಮಾಡಲು ಬೋಧನೆಯು ವಿಫಲವಾಗಿದೆ.

ಭಾಗ–III : Mathematics Textbook

1. ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕವು ಅಂದವಾಗಿದ್ದು ವಿದ್ಯಾರ್ಥಿಗಳು ಓದಲು ಆಸಕ್ತಿ ವಹಿಸುವಂತೆ ಇದೆ.

2. ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದ ಮೊದಲ ಕವರಿನ ಮೇಲ್ಭಾಗದಲ್ಲಿ ಸ್ಕೇಲ್, ತ್ರಿಜ್ಯ, ತ್ರಿಕೋನ ಮತ್ತು ರಬ್ಬರ್, ಬೀಜಗಣಿತದ ಲೆಕ್ಕಗಳನ್ನು ಒಳಗೊಂಡಿದ್ದು ಆಕರ್ಷಕವಾಗಿದೆ.

3. ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದ ಕವರುಗಳು ತೆಳುವಾಗಿದ್ದು ಕಳಪೆ ಮಟ್ಟದಿಂದ ಕೂಡಿದೆ

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4	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದ ಹೊರಗಿನ ಕವಚದ ಭಾಗದಲ್ಲಿ ಯಾವುದೇ ತರಹದ ಚಿತ್ರವನ್ನು ಹೊಂದಿಲ್ಲದ ಕಾರಣ ಈ ಪಠ್ಯಪುಸ್ತಕವು ತನ್ನ ಅಂದತ್ವವನ್ನು ಕಳೆದುಕೊಂಡಿದೆ.
5	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದ ಮುದ್ರಣವು ಚೆನ್ನಾಗಿ ಮುದ್ರಿತವಾಗಿರುವದಿಲ್ಲ.
6	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕವು ಬೀಜಗಣಿತ ಮತ್ತು ರೇಖಾಗಣಿತದ ವಿಷಯಗಳನ್ನು ಒಳಗೊಂಡಿರುವದರಿಂದ ಹೆಚ್ಚು ಆಕರ್ಷಕವಾಗಿದೆ.
7	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದಲ್ಲಿ ರಾಷ್ಟ್ರಗೀತೆಯನ್ನು ಮೊದಲ ಪುಟದಲ್ಲಿ ಮುದ್ರಿಸಬೇಕಾಗಿತ್ತು ಆದಕ್ಕಾಗಿ ಸಮರ್ಪಕವಾಗಿಲ್ಲ.
8	ಪಠ್ಯಪುಸ್ತಕದ ಕೊನೆಯ ಭಾಗದಲ್ಲಿ ನಾಗರೀಕನ ಕರ್ತವ್ಯಗಳ ಬಗ್ಗೆ ತಿಳಿಸುವದರಿಂದ ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯು ಮುಂದೆ ತನ್ನ ಕರ್ತವ್ಯಗಳನ್ನು ಈಗಲೇ ತಿಳಿಯಲು ಸಹಾಯಕವಾಗಿದೆ.
9	ಈ ಪಠ್ಯಪುಸ್ತಕದ ಮುಖ ಪುಟದಲ್ಲಿ ಮೂಡಿಬಂದ ಚಿತ್ರಗಳಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಗಣತ ವಿಷಯದ ಬಗ್ಗೆ ಹೆಚ್ಚು ಆಲೋಚನಾ ಶಕ್ತಿಯನ್ನು ಬೆಳೆಸುವಲ್ಲಿ ಸಹಾಯಕಾರಿಯಾಗಿದೆ.
10	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದ ಮುದ್ರಣಕ್ಕೆ ಬಳಸಲಾದ ಹಾಳೆಗಳು ಕಳಪೆ ಮಟ್ಟದ್ದಾಗಿವೆ.
11	ಪಠ್ಯಪುಸ್ತಕದ ಕೊನೆಯ ಭಾಗದಲ್ಲಿ ಗಣಿತ ವಿಷಯದ ತಜ್ಞರ ಭಾವಚಿತ್ರವನ್ನು ಕೊಡಬಹುದಾಗಿತ್ತು ಆದಕ್ಕಾಗಿ ಇದು ಹೆಚ್ಚು ಸಮರ್ಪಕವಾಗಿಲ್ಲ.
12	ಪಠ್ಯಪುಸ್ತಕವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಮಾನಸಿಕ ಶಕ್ತಿಯನ್ನು ಮತ್ತು ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸುವ ವಿಧಾನವನ್ನು ತಿಳಿಸಲು ಸಹಾಯಕವಾಗಿದೆ.
13.	ಪಠ್ಯಪುಸ್ತಕವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೊರೆಯಾಗುವಂತ ಬೆಲೆಯನ್ನು ಹೊಂದಿದೆ.
14	ಪಠ್ಯಪುಸ್ತಕವು ಹೆಚ್ಚಿನ ಅಂಧತ್ವವನ್ನು ಒಳಗೊಂಡಿಲ್ಲದ ಕಾರಣ ವಿದ್ಯಾರ್ಥಿಗಳ ಗಮನ ಕೇಂದ್ರಿಕರಿಸಲು ವಿಫಲವಾಗಿದೆ.
15	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕವು ಅಂಕಿ ಸಂಖ್ಯೆಗಳ ಜೊತೆಗೆ ಚಿತ್ರಗಳನ್ನು ಒಳಗೊಂಡಿರುವದರಿಂದ ಹೆಚ್ಚು ಆಕರ್ಷಕವಾಗಿದೆ.

ಭಾಗ–IV : Mathematics Syllabus

1	ಗಣಿತ ಪಠ್ಯಪುಸ್ತಕದ ವಿಷಯ ಸೂಚಿಯು ಕ್ರಮಾನುಗತದಿಂದ ಕೂಡಿದ್ದು ಉತ್ತಮವಾಗಿದೆ.
2.	ಗಣಿತ ವಿಷಯವು ರೇಖಾಗಣಿತದ ಪ್ರಮೇಯಗಳ ಬಗ್ಗೆ ವಿವರವಾಗಿ ತಿಳಿಸುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಗಮನ ಸೆಳೆಯುವದು.
3	ಗಣಿತ ವಿಷಯ ಸೂಚಿಯು ಸಂಧರ್ಭಕ್ಕೆ ತಕ್ಕಂತೆ ಚಿತ್ರಗಳನ್ನು ಬಳಸಿಲ್ಲ ಆದಕ್ಕಾಗಿ ಇದು ವಿದ್ಯಾರ್ಥಿಗಳ ಗಮನ ಸೆಳೆಯುವಲ್ಲಿ ವಿಫಲವಾಗಿದೆ.
4.	ಗಣಿತ ವಿಷಯವು ಬೀಜಗಣಿತ, ಅಂಕಗಣಿತ ವಿಷಯಗಳನ್ನು ಹೊಂದಿರುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಅಂಕಿ ಸಂಖ್ಯೆಗಳ ಬಗ್ಗೆ ತಿಳಿಸಲು ಸಹಾಯಕವಾಗಿದೆ.
5.	ಗಣಿತ ವಿಷಯವು ಗ್ರಾಫ್‌ಗಳ ಬಗ್ಗೆ ತಿಳಿಸುವದರಿಂದ ಹೆಚ್ಚು ಆಕರ್ಷಕವಾಗಿದೆ.
6.	ಗಣಿತ ವಿಷಯವು ಆಕರ್ಷಕವಾದ ಬಣ್ಣದ ಚಿತ್ರಗಳನ್ನು ಒಳಗೊಂಡಿಲ್ಲ.
7.	ಗಣಿತ ವಿಷಯವು ಹೆಚ್ಚಿನ ಉದಾಹರಣೆಗಳನ್ನು ಒಳಗೊಂಡಿಲ್ಲದ ಕಾರಣ ಇದು ಸಮರ್ಪಕವಾಗಿಲ್ಲ.

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8	ಗಣಿತ ವಿಷಯವು ಭಾರತೀಯ ಗಣಿತ ತಜ್ಞರ ವಿಷಯಗಳನ್ನು ಒಳಗೊಂಡಿಲ್ಲದ ಕಾರಣ ವಿದ್ಯಾರ್ಥಿಗಳ ಗಮನ ಕೇಂದ್ರೀಕರಿಸಲು ವಿಫಲವಾಗಿದೆ.
9	ಗಣಿತ ವಿಷಯ ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾನಸಿಕ ಶಕ್ತಿಯನ್ನು ಹೆಚ್ಚಿಸಿಕೊಳ್ಳುವಂತ ವಿಷಯವನ್ನು ಹೊಂದಿಲ್ಲ.
10	ಗಣಿತ ವಿಷಯವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಅಂಕಿ ಸಂಖ್ಯೆಗಳ ಬಗ್ಗೆ ತಿಳಿಯಲು ಸಹಾಯಕವಾಗಿದೆ.
11	ಗಣಿತ ವಿಷಯವು ಆಧುನಿಕ ಜೀವನಕ್ಕೆ ಸರಿದೂಗುವಂತ ವಿಷಯವನ್ನು ಒಳಗೊಂಡಿಲ್ಲ.
12	ಗಣಿತ ವಿಷಯವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ವ್ಯವಹಾರಿಕ ಜ್ಞಾನವನ್ನು ಹೆಚ್ಚಿಸಲು ಸಹಾಯಕವಾಗಿದೆ.
13	ಗಣಿತ ವಿಷಯವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ನಿಖರವಾದಂತಹ ಉತ್ತರವನ್ನು ಪಡೆಯಲು ಸಹಯಕವಾಗಿದೆ.
14	ಗಣಿತ ವಿಷಯವು ಹೆಚ್ಚಾಗಿ ಅಂಕಿ ಸಂಖ್ಯೆಗಳಿಂದ ಕೂಡಿರುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಗೊಂದಲ ಉಂಟುಮಾಡಿ ಅವರ ಆಸಕ್ತಿಯನ್ನು ಕೆರಳಿಸಲು ವಿಫಲವಾಗಿದೆ.

ಭಾಗ–V : Evaluation in Mathematics

1 ಗಣಿತದಲ್ಲಿ ಮೌಲ್ಯಮಾಪನವನ್ನು ಒಂದು ಅಧ್ಯಾಯ ಮುಗಿದ ನಂತರ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಆ ಅದ್ಯಾಯಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಕೆಲವು ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸಿಕೊಂಡು ಬರಲು ತಿಳಿಸುವದರ ಮೂಲಕ ಅದು ಯಶಸ್ವಿಯಾಗುವದು.

2. ಗಣಿತದ ಮೌಲ್ಯಮಾಪನಕ್ಕೆ ಕಪ್ಪು ಹಲಗೆಯನ್ನು ಹೆಚ್ಚು ಬಳಸುವದರಿಂದ ಅದು ಹೆಚ್ಚು ಸಮರ್ಪಕವಾಗುವದು.

3 ಗಣಿತದ ಮೌಲ್ಯಪನದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಬೀಜಗಣಿತ, ಅಂಕಗಣಿತ ರೇಖಾಗಣಿತಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸಲು ಹೇಳುವದರ ಮುಖಾಂತರ ಮೌಲ್ಯಮಾಪನವು ಹೆಚ್ಚು ಸಮಂಜಸವೆನಿಸುವದು.

4. ಎಲ್ಲಾ ವಿದ್ಯಾರ್ಥಿಗಳು ಒಂದೊಂದು ತರಹದ ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸಿಕೊಂಡು ಬರುವದರಿಂದ ನಿಖರವಾದ ಉತ್ತರ ದೊರೆಯದೆ ಮೌಲ್ಯಮಾಪನವು ವಿಫಲವಾಗುವದು.

5. ಗಣಿತ ಮೌಲ್ಯಮಾಪನ ಕೇವಲ ಪ್ರಾಯೋಗಿಕ ವಿಷಯವನ್ನು ಹೊಂದಿರುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಆಸಕ್ತಿಯನ್ನು ಹೊಂದುವಂತೆ ಮಾಡಲು ವಿಫಲವಾಗಿದೆ.

6 ಗಣಿತ ಮೌಲ್ಯಮಾಪನವು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಅಂಕಿ ಸಂಖ್ಯೆಗಳ ಜ್ಞಾನವನ್ನು ಬೆಳೆಸುವಲ್ಲಿ ಯಶಸ್ವಿಯಾಗಿದೆ.

7. ಗಣಿತ ಮೌಲ್ಯಮಾಪನದ ಸಮಯದಲ್ಲಿ ಅಂಕಿ ಸಂಖ್ಯೆಗಳ ಪ್ರಶ್ನೆಗಳನ್ನು ಹೆಚ್ಚು ಕೇಳುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಗಮನ ಸೆಳೆಯುವಲ್ಲಿ ವಿಫಲವಾಗಿದೆ.

8 ಗಣಿತ ಮೌಲ್ಯಮಾಪನದಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ನಿತ್ಯ ಜೀವನದಲ್ಲಿ ಲೆಕ್ಕಗಳ ಕುರಿತು ತಿಳಿಯಲು ಸಹಾಯಕವಾಗಿದೆ.

9 ಗಣಿತ ಮೌಲ್ಯಮಾಪನದಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ವ್ಯವಹಾರಿಕ ಜ್ಞಾನವನ್ನು ಬೆಳೆಸುವಲ್ಲಿ ಸಹಾಯಕವಾಗಿದೆ.

10 ಗಣಿತ ಮೌಲ್ಯಮಾಪನದಲ್ಲಿ ಹೆಚ್ಚಾಗಿ ಸಂಖ್ಯೆಗಳು ಕುರಿತು ಇರುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಗೊಂದಲ ಮೂಡಿ ಆಸಕ್ತಿ ಕೆರಳಿಸಲು ವಿಫಲವಾಗಿದೆ.

11. ಗಣಿತ ಮೌಲ್ಯಮಾಪನದಲ್ಲಿ ಒಂದೇ ಮಾದರಿಯ ಪ್ರಶ್ನೆಗಳನ್ನು ಕೇಳುವದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಆಸಕ್ತಿ ಕೆರಳಿಸಲು ವಿಫಲವಾಗಿದೆ.

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12	ಗಣಿತ ಮೌಲ್ಯಮಾಪನದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಆಸಕ್ತಿಯನ್ನು ಕೆರಳಿಸುವಂತ ಪ್ರಶ್ನೆಗಳು ಕಡಿಮೆ ಆದ್ದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ಮೌಲ್ಯಮಾಪನದಿಂದ ತಪ್ಪಿಸಿಕೊಳ್ಳಲು ಪ್ರಯತ್ನಿಸುತ್ತಾರೆ.

ಭಾಗ–VI : Mathematics as a Subject

1	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ತಮ್ಮ ದಿನನಿತ್ಯ ಜೀವನದಲ್ಲಿ ಎದುರಿಸುವ ಗಣಿತದ ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸುವಂತೆ ಸಹಾಯ ಮಾಡುವದು.
2	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಬುದ್ಧಿಶಕ್ತಿಯನ್ನು ಹೆಚ್ಚಿಸಿಕೊಂಡು ಮಾನಸಿಕ ಶಿಸ್ತನ್ನು ಪಡೆಯುವಂತೆ ನೆರವಾಗುವದು.
3	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಸೌಂದರ್ಯೋಪಾಸನೆ ಸಾಮರ್ಥ್ಯಗಳನ್ನು ಬೆಳೆಸಲು ವಿಫಲವಾಗಿದೆ.
4	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಬಿಡುವಿನ ವೇಳೆಯನ್ನು ಸದುಪಯೋಗ ಪಡಿಸಿಕೊಳ್ಳುವಂತೆ ಮಾಡಲು ವಿಫಲವಾಗಿದೆ
5	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳು ಗಣಿತದ ಸಮಸ್ಯೆಗಳನ್ನು ಬಿಡಿಸುವಲ್ಲಿ ಸ್ವಾವಲಂಬಿಗಳನ್ನಾಗಿ ಮಾಡುವದು.
6.	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳು ಗಣಿತ ವಿಷಯದ ವಿಭಾಗಗಳನ್ನು ಹಾಗೂ ಬೇರೆ ಬೇರೆ ಪಾಠಗಳ ಸಂಬಂಧವನ್ನು ಆಂತರಿಕವಾಗಿ ತಿಳಿಯುವಂತೆ ಮಡುವದು.
7.	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳ ನೈತಿಕ ಮಟ್ಟವನ್ನು ಹೆಚ್ಚಿಸುವದು ನೀತಿ ನಿಯಮಗಳನ್ನು ಪಾಲಿಸಿ ಆದರ್ಶ ಜೀವನವನ್ನು ನಡೆಸುವಂತೆ ಸಹಾಯಮಾಡುವದು.
8	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳು ಸಂಸ್ಕೃತಿ ಹಾಗೂ ನಾಗರೀಕತೆಯ ಬೆಳವಣಿಗೆಯಲ್ಲಿ ಗಣಿತದ ಹೊಂದಾಣಿಕೆಯನ್ನು ತಿಳಿಯುವಂತೆ ಮಾಡುವದು.
9	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳು ಸರಳ ಹಾಗೂ ಉತ್ತಮ ಜೀವನವನ್ನು ನಡೆಸುವಂತೆ ತಿಳಿ ಹೇಳಲು ವಿಫಲವಾಗಿದೆ.
10.	ಗಣಿತ ಅಧ್ಯಾಯನವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಇತರ ವಿಷಯಗಳನ್ನು ಹಾಗೂ ಗಣಿತದ ಉನ್ನತ ಅಭ್ಯಾಸವನ್ನು ಮಾಡುವಂತೆ ಸಹಾಯ ಮಾಡಲು ವಿಫಲವಾಗಿದೆ.

APPENDIX – VIII

ANSWER SHEET

ಹೆಸರು :

ವರ್ಗ :

ಶಾಲೆಯ ಹೆಸರು :

ಪಟ್ಟಣ/ಗ್ರಾಮ :

ಲಿಂಗ: ಗಂಡು/ಹೆಣ್ಣು

ಕ್ರ.ಸಂ.	ಯಾವಾಗಲೂ	ಮೇಲಿಂದ ಮೇಲೆ	ಯಾವಾಗಲಾದರೂ ಒಮ್ಮೆ	ಅಪರೂಪವಾಗಿ	ಯಾವಾಗಲೂ ಇಲ್ಲ
ಭಾಗ–I : Mathematics Teacher					
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐
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13	☐	☐	☐	☐	☐
ಭಾಗ–II : Methods of Teaching Mathematics					
1	☐	☐	☐	☐	☐
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3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
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8	☐	☐	☐	☐	☐
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10	☐	☐	☐	☐	☐
ಭಾಗ–III : Mathematics Textbook					
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐

ಕ್ರ.ಸಂ.	ಯಾವಾಗಲೂ	ಮೇಲಿಂದ ಮೇಲೆ	ಯಾವಾಗಲಾದರೂ ಒಮ್ಮೆ	ಅಪರೂಪವಾಗಿ	ಯಾವಾಗಲೂ ಇಲ್ಲ
10	☐	☐	☐	☐	☐
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14	☐	☐	☐	☐	☐
15	☐	☐	☐	☐	☐
ಭಾಗ–IV : Mathematics Syllabus					
1	☐	☐	☐	☐	☐
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14	☐	☐	☐	☐	☐
ಭಾಗ–V : Evaluation in Mathematics					
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ಭಾಗ–VI : Mathematics as a Subject					
1	☐	☐	☐	☐	☐
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